NOLOGY DEPT.

Electronic Engineering

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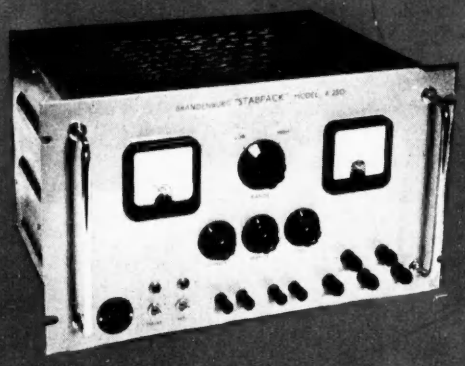
DECEMBER 1955



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high voltage engineering

see page 113

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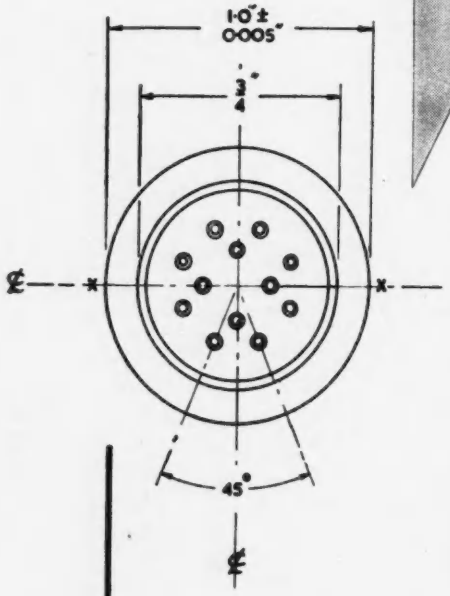

Ediswan, who have specialized for many years in the production of hermetic seals, offer a wide range of Standard Metal-Glass Seals of first-class quality.

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Experience has proved that these standard seals meet the majority of requirements, but our Engineers will be pleased to discuss applications outside the scope of this range.

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THE EDISON SWAN ELECTRIC Co. Ltd., 155 Charing Cross Road, London, W.C.2 and Branches

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CLASSIFIED ANNOUNCEMENTS

The charge for these advertisements is 6d. per word. Minimum charge 12/-. Box number 2/- extra, except in the case of advertisements for "Situations Wanted," when it is free. Specially spaced advertisements per inch single column 42/6. A remittance must accompany the advertisement. Replies to Box numbers should be addressed to: "Electronic Engineering," 28, Essex Street, Strand, London, W.C.2. Advertisements must be received before the 14th of the month for insertion in the following issue.

OFFICIAL APPOINTMENTS

APPLICATIONS ARE INVITED for pensionable posts as Assistant Examiners in the Patent Office to undertake the official scientific technical and legal work in connection with Patent Applications. There are a small number of similar posts in the Ministry of Supply. Applications may be accepted up to 31st December, 1955, but early application is advised. Interview Boards will sit at frequent intervals. Candidates must be between 21 and 28 years of age during 1955 (up to 31 for permanent members of the Experimental Officer Class) and have First or Second Class Honours Degree in physics, chemistry, mechanical or electrical engineering or mathematics. Candidates taking their Degrees in 1955 may apply before the results of their Degree examination is known. Starting emoluments in London, including Extra Duty Allowance for 45½ hour week, between £554 and £761 (men), £674 (women), according to periods of National Service and post-graduate experience rising to £939 (men), and £842 (women). Promotion to Examiners, £977 to £1,344 (men), £863 to £1,209 (women); normally after 5 years (3 or 4 years in exceptional cases). Women's scales subject to increase under equal pay scheme. Good expectation of promotion to Senior Examiner. Candidates are recruited by selective interview. Application forms and further information from the Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting number S128/55. W 3743

ASSISTANTS (SCIENTIFIC). The Civil Service Commissioners invite applications for pensionable posts. Age at least 17½ and under 26 years of age on 1st January, 1955, with extension for regular service in H.M. Forces, but candidates over 26 with specialized experience may be admitted. Candidates must produce evidence of having reached a prescribed standard of education, particularly in a science or mathematical subject. At least two years' experience in the duties of the class gained by service in a Government Department or other civilian scientific establishment or in technical branches of the Forces essential in one of the following groups of scientific subjects: (i) Engineering and physical sciences. (ii) Chemistry, bio-chemistry and metallurgy. (iii) Biological Sciences. (iv) General (including geology, meteorology, general work ranging over two or more groups (i) to (iii) and highly skilled work in laboratory crafts such as glass-blowing). Inclusive salary scale £280 (at 18) to £575 (men) or £490 (women). Starting pay up to £423 (men) or £380 (women) at 25. Women s pay subject to improvement under Equal Pay scheme. Somewhat less in the provinces. Opportunities for promotion. Further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S 59/55. Completed applications should be returned as soon as possible and in any case not later than 31st December, 1955. W 3771

ATOMIC ENERGY RESEARCH ESTABLISHMENT, Harwell has vacancies in its Engineering Services and Health Physics Divisions for Technicians for fault finding, testing and calibration of a wide range of electronic instruments. Some of the posts will involve work on instruments designed for the control of radiation hazards. Applicants should have served a recognized engineering apprenticeship and have good subsequent experience of electronic engineering. Some knowledge of industrial instruments would be an advantage. Technical qualifications of Ordinary or Higher National Certificate standard is desirable, but candidates without these qualifications but having a wide practical electronic experience will be considered. Appointments will be made according to age, experience and qualifications, within one of the following scales: Technical Class Grade II £743 (linked to age 30) to £873 p.a. Technical Class Grade III £608 (linked to age 26) to £748 p.a. Officers selected for the above appointments will be required to join the authority's contributory superannuation scheme. Requests for application form on a postcard to the Establishment Officer, U.K. Atomic Energy Authority, A.E.R.E., Harwell, Didcot, Berks, quoting reference 2/103/342 and 386. W 3764

AIR MINISTRY requires two scientists in the department of the Scientific Adviser to lead teams concerned with study of (i) new techniques for improvement of R.A.F. electronic equipment (post A); (ii) technical supply and economic problems of operation of military aircraft and guided weapons systems (post B). Qualifications: Post A first or second-class Honours Degree in physics or electrical engineering, with an interest in the wider aspects of physics and a good background of research or practical experience in fundamentals of design and calculation of performance of radar equipments or some closely allied electronic equipment. Post B first or second-class Honours Degree in mechanical, electrical or aeronautical engineering, together with industrial or research experience and preferably an interest in applied statistical methods. Appointments in London on Principal or Senior Scientific Officer scales (£1,245-£1,595 or £1,070-£1,245 respectively) according to experience. F.S.S.U. available. Application forms quoting D488/5A from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1. W 3756

B.B.C. TELEVISION ENGINEERS required for projects involving wide range of Television equipment used for Studio Broadcasting, Outside Broadcasting, Film Transmission including planning, testing and setting to work, and variety of allied technical problems. Degree in Elec. Eng. or Physics or equivalent essential, good knowledge of principles of Television desirable. This work offers good prospects of advancement. Requests for application forms to Engineering Establishment Officer, Broadcasting House, London, W.1, quoting reference Ex 68 E.E. W 3775

BRITISH EUROPEAN AIRWAYS require Engineers for the maintenance, overhaul and development of Electronic Flight Simulators. Applicants should possess a sound basic knowledge of electronics and have experience in positional and rate servos accurate repeater mechanism, etc. Salary on probation £635 p.a. increasing to £679 p.a. after approximately six months, rising to £775 p.a. maximum in grade. Additional payment for shifts. Written applications to Personnel Officer, Flight Operations Department, B.E.A., Keyline House, Ruislip, Middlesex. W 3733

COLLEGE OF TECHNOLOGY. Birmingham. Department of Physics and Mathematics. There is a vacancy for a Research Assistant in electronics. Candidates must have a good Honours Degree in physics, preferably from a University which awards higher Degrees externally. The appointment involves a small amount of teaching. The salary is in accordance with the Burnham (Further Education) Scale for Grade A Assistants. Basic salary (men) £510, (women) £453 (plus equal pay increment) with increments for approved training and industrial or teaching experience. Further particulars and form of application may be obtained from the Registrar, College of Technology, Suffolk Street, Birmingham, 1, on receipt of stamped addressed foolscap envelope. Completed forms should be returned to him not later than two weeks after the insertion of the advertisement. W 3725

ELECTRONICS PHYSICISTS OR ENGINEERS required at Ministry of Supply Research and Development Establishment, Waltham Abbey, Essex, for experimental design and development of apparatus in particular for measurement of high speed phenomena. Quals.: H.S.C. (Science) or equivalent, but H.N.C. or Degree in Physics or Electrical Engineering may be an advantage. Salary within Experimental Officer range (min. age 26): £790-£960. Equal pay scheme. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A 397/5A. Closing date 9th December, 1955. W 3776

ELECTRONICS RESEARCH ASSISTANT wanted in physiological laboratory. Duties: to develop and construct apparatus (mainly electronic) for nerve and muscle research. EEG/EMG/CRO—photography or general workshop experience an advantage. Salary £570×£25 to £670 p.a. with superannuation and marriage allowance. Apply in writing to The Secretary, Department of Physiology, The Middlesex Hospital Medical School, London, W.1. W 3734

ENGINEERS. The Atomic Weapons Research Establishment, Aldermaston, Berkshire. Post (a) Ref. No. 793/42 (Main and Basic Grades) for project design including technical supervision of drawing office effort and specification writers, liaison between scientific staff, agencies and industrial contractors. Candidates should have served a recognized apprenticeship and be Corporate Members of the Institute of Electrical or Mechanical Engineers or hold exempting qualifications. Experience in the following fields would be an advantage. (1) Design of pulsed high voltage electrical equipment for airborne use. (2) Design of electrical or electronic equipment for use in missiles. Post (b) Ref. No. 794/42 (Basic Grade) for the development of electrical electro-mechanical and electronic components and circuits for use under weapons conditions. Candidates should have served a recognized apprenticeship and be Corporate Members of the Institute of Electrical Engineers or hold exempting qualifications. Experience in the following fields would be an advantage. (1) The development of electronic components and circuits to function under severe conditions of climate and vibration. (2) High voltage pulse generation. (3) Spark gap devices. Salary: Main Grade £1,130-£1,435 p.a. (male). Basic Grade £728 (linked to age 25) to £1,130 p.a. (male). Contributory Superannuation Scheme. Successful married officers now living outside the Establishment's transport area will be eligible for housing on one of the Authority's estates, alternatively assistance towards legal expenses incurred in house purchase will be payable. Until housed a lodging allowance may be payable. Requests for application forms by postcard to Senior Recruitment Officer, at the above address, quoting the appropriate reference number. W 3783

EXPERIMENTAL OFFICERS and Assistant Experimental Officers required by The Atomic Weapons Research Establishment, Aldermaston, Berkshire. Post (a) Ref. No. 795/42 to assist in work on problems involving high energy electrical discharges through gases over a wide range of pressures. The work requires the operation of high voltage and vacuum equipment together with transient recording apparatus. Experience with transient oscillography or vacuum techniques is desirable. Post (b) Ref. No. 796/42 the development and use of electronic and electrical equipment for weapons trials. Experience in the following fields is desirable:— High speed oscillography, high voltage pulse generation or detonation measurements. Possession of H.N.C. in Electrical Engineering or Physics an advantage. Post (c) Ref. No. 797/42 the development of electrical and electronic components for use under weapon conditions. Experience in the following fields is desirable:— the testing of electronic components and circuits subject to severe conditions of climate and vibration high voltage pulse generation and spark gap devices. H.N.C. in Electrical Engineering advantageous. Minimum qualifications for all posts is H.S.C. (Science) or equivalent and applicants for the Experimental Officer posts should be at least 26 years of age. Salary: Experimental Officer £808-£988 p.a. (male). Assistant Experimental Officer £330 linked to age 18 to £718 p.a. (male). Contributory Superannuation Scheme. Married officers now living outside the Establishment's transport area will be eligible for housing on one of the Authority's estates, alternately assistance towards legal expenses incurred in house purchase will be payable. Until housed a lodging allowance may be payable. Requests for application forms by postcard to Senior Recruitment Officer at the above address, quoting the appropriate reference number. W 3772

OFFICIAL APPOINTMENTS (Cont'd.)

GOLD COAST GOVERNMENT, Broadcasting Engineers. Applications are invited for appointment as Assistant in Engineering Training (Radio Frequency). Duties: Responsible under the Head of Engineering Training for the training of pupils scattered in small groups over wide areas by lectures and postal courses up to approximately the standard of the B.B.C.'s Grade C examination with emphasis on radio frequency subjects and on the theory and operation of radio frequency equipment. Will also be required to carry out some operational duties. Qualifications: Candidates should have passed or have been exempted from Sections A and B of the Associate Membership examination of the Institution of Electrical Engineers or hold equivalent qualifications. Candidates with exceptional experience but not so qualified may be considered for appointment. Candidates should have a thorough knowledge of transmitter, aerial and feeder systems, receivers, etc. and should also have sound knowledge of the fundamental theory of audio frequency and power frequency equipment and be capable of lecturing on these subjects. Previous teaching experience is desirable. Terms of Service: The appointment will be on contract/gratuity terms for one tour of 18 to 24 months with extension provision to two tours. Salary in range £1,600-£2,050 according to age, qualifications and experience. Gratuity at rate of £12 10s. for each completed month's satisfactory service. Free passages appointment and on leave for officer; once each way for wife and up to three children under 13 years each tour. Vacation leave with pay seven days for each month's service. Kit allowance £30 may be payable. Basically furnished accommodation at £90 p.a. rental. Income tax at low rates. Candidates should apply to the Adviser on Recruitment, Gold Coast Office, 13 Belgrave Square, London, S.W.1, for a form of application. W 3749

HERTFORDSHIRE COUNTY COUNCIL, Hatfield Technical College, Roe Green, Hatfield. Principal: Dr. W. A. J. Chapman, M.Sc. (Eng.). Applications are invited for the post of Assistant Grade B in Electrical Engineering. Candidates should be graduates in Electrical Engineering, or possess equivalent in professional qualifications, and have appropriate industrial experience. Preference will be given to candidates with experience in the U.H.F. field. Applicants should be able to lecture in Electronics and Telecommunications up to H.N.C. level and to develop work in these subjects to final Degree standard. The successful applicant will be required to commence duties as soon as possible. Applications (no forms issued) should be sent to the Registrar within 14 days of the appearance of this advertisement, together with the names and addresses of two referees and copies of two recent testimonials. W 1443

MECHANICAL AND ELECTRICAL ENGINEERS in various Government Departments. The Civil Service Commissioners invite applications for pensionable posts in a wide variety of mechanical and electrical engineering duties. Candidates must be under 35 on 1st January, 1955, with extension for regular service in H.M. Forces and up to two years for permanent civil service. For the Post Office they must be at least 21, for the Ministry of Supply, and Ministry of Transport and Civil Aviation (Civil Aviation Organization) at least 23; for other posts at least 25 on that dae. Generally a candidate must possess a University Degree in Engineering or be a Corporate Member of one of the professional institutions — Mechanical Engineers, Electrical Engineers or Civil Engineers or have passes in, or exemption from, Section A or I and B or II of the corresponding Associate Membership examinations. Exceptionally candidates of high professional attainment, but without the specified qualifications, may be admitted. For some posts Associate Fellowship of the Royal Aeronautical Society or an Honours Degree in Physics or Engineering will be accepted. London salary (men) £705 (at age 25) to £1,095. Starting salary according to age up to £907 at 34. Candidates entering below age 25 will start at salaries varying from £493 at age 21 to £625 at age 24. Prospects for promotion. Salaries of next higher grades are £1.095-£1,415 and £1,595. Somewhat lower in the Provinces. Women's scales lower but being improved under equal pay scheme. Further particulars and application forms from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S85/55. Completed applications should be returned as soon as possible and in any case before 31st December, 1955. W 3741

MID-ESSEX TECHNICAL College and School of Art, Market Road, Chelmsford. Required as soon as possible:— Lecturer in Telecommunications to take charge of Radio H.N.C. Courses and C. and G. Telecommunications courses. Graduate or equivalent qualification required. Assistant Grade B to assist with Radio H N.C., O.N.C., C. and G. Telecommunications Courses. Graduate or equivalent qualifications desirable. Salaries according to the Burnham Further Education Report 1954. Details and forms (stamped, addressed foolscap envelope) from the Clerk to the Governors at the College. W 3779

MINISTRY OF SUPPLY, Radar Research Establishment, Malvern, Worcs, requires Physicist and Electrical Engineers for research and development work, mainly on radar and electronic equipment. Work ranges from fundamental research on circuitry and physics of solids to devising and developing electronic devices. Quals., First or Second-class Honours Degree or equivalent in Physics or Electrical Engineering. Appointments A.Q.E. as Senior Scientific Officer (min. age 26) or Scientific Officer (min. age 21). At least three years' post graduate research experience for senior grade. Salary within range S.S.O. £1,030-£1,185; S.O. £488 10s. to £885 (superannuable). Equal pay scheme. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A 386/5A. Closing date 9th December, 1955. W 3740

MINISTRY OF SUPPLY require Experimental Officers in Radio Division of Royal Aircraft Establishment, Farnborough, Hants. Work chiefly concerned with development of electronic equipment, radio frequency, measurements of centimetric wavelengths and other detailed technical investigation. Quals.: Higher School Certificate (Science) or equivalent but Degree in Physics or Elec. Engineering. H.N.C. or final C. and G. Certificate in Telecommunications may be an advantage. Salaries according to age, experience, etc. in ranges Experimental Officer (min. age 26) £745-£920 or Assistant E.O. £306 10s. (age 18) to £670. Women's salary subject to equal pay scheme. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D499/5A. W 3762

MINISTRY OF TRANSPORT and Civil Aviation. Radio Technicians. Appointments available for interesting work providing and maintaining aeronautical telecommunications and electronic navigational aids at aerodromes and radio stations in various parts of the U.K. Applications invited from men aged 19 or over who have fundamental knowledge of radio or radar with some practical experience. Training courses provided to give familiarity with types of equipment used. Salary £467 10s. 0d. age 25, rising (subject to a practical test) to £565. Rates lower in Provinces and for those below age 25. Prospects of permanent pensionable posts for those who qualify. Opportunities for promotion to Telecommunications Technical Officer are good for those who obtain O.N.C. in Electrical Engineering or certain C.G. Certs. Maximum salaries of Telecommunications Technical Officers: Grade III £695, Grade II £810, Grade I £985. Apply to Ministry of Transport and Civil Aviation (ESB1/RT), Berkeley Square House, London, W.1, or any Employment Exchange quoting Order No. Westminster 6627. W 3713

SENIOR SCIENTIFIC OR SCIENTIFIC OFFICER required by Ministry of Supply at Guided Weapons Dept., R.A.E., Farnborough, for development of radar systems for guided weapons. Quals.: First or Second Class Honours Degree or equivalent in Physics or Electrical Engineering. Experience in any of following useful:— radar systems, microwaves, servo mechanisms or automatic controls Appointment A.Q.E., as S.S.O. (min. age 26) or S.O. (min. age 21) three years' post graduate research experience essential for S.S.O. Salary within ranges, S.S.O., £1,030-£1,185: S.O., £488 10s. to £885 (superannuable). Equal pay scheme. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street. London, S.W., quoting A.406/5A. Closing date 9th December, 1955. W 3768

THE UNIVERSITY OF MANCHESTER. There are vacancies in the Department of Chemistry for four Technicians. For one vacancy a knowledge of electronics is required. An appointment in the grade of Senior Technician may be made for this post. Salary in accordance with the University's scales for Technicians, and with membership of a Superannuation Scheme. Applications should be sent to the Chief Technician. The Department of Chemistry, The University. Oxford Road, Manchester, 13. W 3705

TRINITY HOUSE, LONDON. Applications are invited for appointment to the following posts:— (a) Experimental Officer (Unestablished) to take charge of a small experimental station on the south coast. The duties will comprise the testing of various types of navigational aid equipment and knowledge of electronic instrumentation will be required. (b) Experimental Officer (Unestablished) for research and development work at Trinity House, London. The duties will include the study and use of large power sound signals. A knowledge of the mathematical treatment of sound waves will be useful. Qualifications for both above posts:— Higher National Certificate or equivalent. (c) Assistant Engineer (Unestablished). This post is for an assistant to the officer-in-charge of the south coast experimental station above, and will involve work along the same lines. Qualifications:— Ordinary National Certificate or equivalent and apprenticeship giving a good comprehensive training. Salary Scales for (a) and (b):— (London) £720×£25—£770×£30—£890 p.a. basic; (Provinces) £690×£25—£735×£30—£850 p.a. basic. For (c) (Provinces) £510 (at age 26)×£20—£550×£25—£640 basic. In all cases pay supplement ranging from £55 to £70 will be paid in addition. Applications should be made in writing to the Secretary, Trinity House, Tower Hill, London, E.C.3, not later than 17th December, 1955, and should state age, occupation, qualifications, experience and enclose copies of testimonials. W 3763

UNIVERSITY COLLEGE LONDON (Gower Street, W.C.1) require Electronics Technician for research work in Anatomy Dept. Application forms from Secretary, quoting Anatomy/8. W 3773

SITUATIONS VACANT

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 *inclusive or a woman aged* 18-59 *inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order,* 1952.

A JUNIOR ELECTRONIC ENGINEER is required by a food organization situated in N.W. London, to construct and maintain specialized factory installations. Canteen, five-day week, pension scheme. Salary according to age and experience. Write Box E.E.347, c/o 191 Gresham House, E.C.2. W 3774

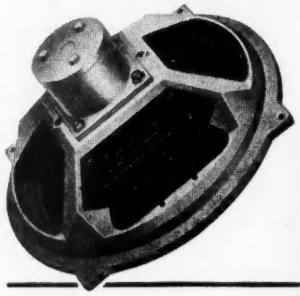
ALUMINIUM LABORATORIES LIMITED, Banbury, require male and female technicians to work on instrumentation development for the light metal industry. The fields involved are as follows:— Research on inspection methods. Construction and maintenance of instruments. Measurements and calibration. Experimental design of instruments. The work is interesting and progressive, and provides unusual opportunities for men and women with initiative and enthusiasm. The laboratories are situated in pleasant country surroundings and have recently been extended. Salaries will be attractive and in accordance with age and experience. A pension scheme is in operation. Applications should be addressed to:— The Director, Aluminium Laboratories Limited, Banbury, Oxon. W 1432

AN EXPANDING Instrument Company is in need of Physicists, Electronic Engineers, and Chemist. The work to be undertaken by a newly-formed division of the Company is broadly in the field of process control and measurement devices. Qualifications are essential, but the chief requirement is interest in and enthusiasm for the work. These posts will appeal to men under 30 who are anxious to break out of the rut and assist in the development of new ideas. Please write giving brief details of qualifications and experience to Dr. D. H. Parnum, Industrial Division, Southern Instruments Ltd., Camberley, Surrey. W 304

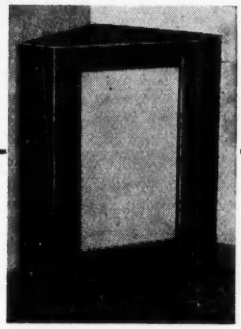
A PHYSICAL CHEMIST or Physicist is required by Consultants on important development work concerning dielectrics and electrical components. The post requires considerable ability and drive and carries a commensurate salary. G. V. Planer Ltd., Hanworth Trading Estate, Hampton Road, Feltham 3399. W 1457

CLASSIFIED ANNOUNCEMENTS
continued on page 4

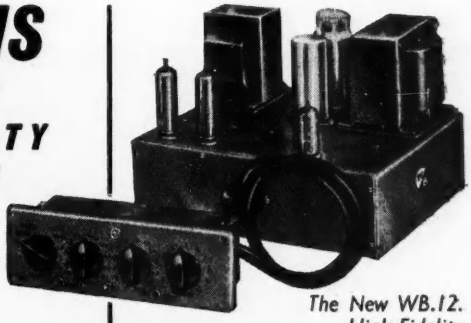
OUTSTANDING ITEMS
IN THE WHITELEY HIGH FIDELITY RANGE



Stentorian Cambric Cone High Fidelity Units. The famous HF1012 at £4.19.9. Others from 47/6.



Ready to assemble Cabinets from £5.10.0. Base Reflex Corner Console. Price £11.11.0.



The New WB.12. High Fidelity Amplifier Price £25.

Hi-Fi Reproducer Console. Price £12.12.0.

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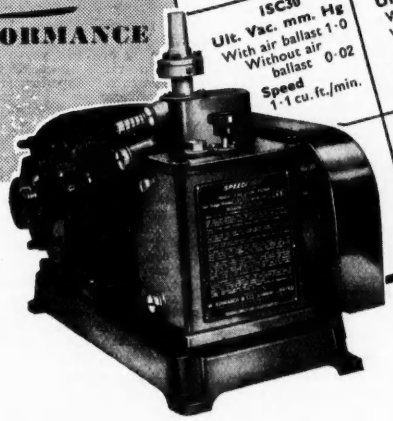
ISC30	ISC50	ISC150	ISC450
Ult. Vac. mm. Hg With air ballast 1·0 Without air ballast 0·02	Ult. Vac. mm. Hg With air ballast 1·0 Without air ballast 0·01	Ult. Vac. mm. Hg With air ballast 1·0 Without air ballast 0·01	Ult. Vac. mm. Hg With air ballast 1·0 Without air ballast 0·01
Speed 1·1 cu. ft./min.	Speed 1·7 cu. ft./min.	Speed 5·1 cu. ft./min.	Speed 15 cu. ft./min.
2SC20	**2SC50**		**2SC150**
Ult. Vac. mm. Hg With air ballast 0·05 Without air ballast 0·001	Ult. Vac. mm. Hg With air ballast 0·005 Without air ballast 0·0002		Ult. Vac. mm. Hg With air ballast 0·005 Without air ballast 0·0002
Speed 0·8 cu. ft./min.	Speed 1·7 cu. ft./min.		Speed 5·1 cu. ft./min.



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AGENTS THROUGHOUT THE WORLD

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 *inclusive or a woman aged* 18-59 *inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order,* 1952.

APPLICATIONS ARE INVITED for the position of Production Manager for a unit of a large engineering company in the London area engaged in the manufacture of vibrators, relays, and other electro-mechanical devices. The successful candidate will have extensive experience of administration, production control, estimating and time study and will be acquainted with the most up-to-date production methods and techniques. For a man with the required qualifications this vacancy presents excellent prospects in a rapidly expanding unit. Please write, giving full details to Box No. W 3706.

APPLICATIONS ARE INVITED from Senior Project Engineers with a specialized knowledge of the Manufacture of Electrical and Mechanical Products. Applicants should have a good practical engineering background and a sound technical experience of tool design and planning and be capable of putting new projects on a sound production basis. These vacancies offer excellent opportunities to men seeking permanent and progressive positions. London area. Applications, which will be treated in confidence, should give full details of experience and salary required and be addressed to Box No. W 3679.

A RESEARCH ENGINEER familiar with the application of Electric Equipment to Mechanical Engineering projects is required to undertake investigations into vibration problems associated with steam turbines. Applicants should preferably have an Engineering Degree, but other qualifications will be considered. A thorough knowledge of strain gauge techniques is essential. The post offers excellent opportunities for further study and advancement in this field. Conditions of service include a generous superannuation and staff bonus scheme. Application to the Chief Personnel Officer, Brush Electrical Engineering Co. Ltd., Loughborough, Leics. W 3724

A SENIOR ELECTRONIC Circuit Designer is required. He must have reasonable academic qualifications and have had several years' experience in the design of radar, pulse or computing circuits. The post offers opportunities for study of a number of new techniques in these fields and, in the case of a suitable applicant, will involve leading a small group. The post is permanent and pensionable and offers excellent opportunities for progress. Applications, giving an outline of academic or other qualifications, experience, stating required starting salary and quoting reference LE/8, should be sent to the Personnel Officer, Ericsson Telephones Limited, Beeston, Nottingham. W 3649

A SENIOR ENGINEER is required for an interesting appointment in the Simulator Department of the English Electric Company, Guided Missiles Division at Luton, Bedfordshire. The successful candidate should have a sound knowledge of Servos and electronic equipment in general, together with considerable knowledge and experience of LF amplifiers. This interesting appointment, which is pensionable after a qualifying period, carries an attractive salary, good working conditions on first-class equipment, and offers ideal prospects in this specialized field. Applications, which will be treated in strict confidence, should state ful details of past experience and qualifications and should initially be addressed to Ref. No. 844P, Dept. C.P.S., 336/7 Strand, W.C.2. W 3728

A. T. & E. (Bridgnorth) Ltd., Bridgnorth, Shropshire, have the following vacancies in their telecommunications drawing offices:— (a) Deputy Chief Draughtsman with several years' experience in the design and checking of telecommunication equipment and electro mechanical apparatus. (b) Draughtsman Designer for work on layout and light engineering products associated with radio and telecommunications. (c) Draughtsman-checker with workshop experience and knowledge of modern production manufacture of electronic and telecommunication equipment. (d) Draughtsmen with workshop experience for design and detailing of electromechanical apparatus. All these posts offer excellent opportunities to keen men in an expanding organization. Salary £500-£850 per annum according to experience. Five-day week, pension scheme, assistance with housing for senior staff where required. Applications to the "Chief Draughtsman", stating age, qualifications and experience. W 3770

A SENIOR ENGINEER is required, to be responsible for the layout, mechanical design and engineering aspects at prototype level of a variety of electronic apparatus. Several years experience in this or a related field is required. The post is permanent, progressive and pensionable. Applications, giving an outline of qualifications and experience, stating salary required and quoting reference LE/E should be sent to the Personnel Officer, Ericsson Telephones Limited, Beeston, Nottingham. W 3650

A VACANCY EXISTS in our London Offices for a Technical Buyer, who must be thoroughly familiar with the Service designations of electronic components and accustomed to purchasing from all leading manufacturers. The successful candidate will have to be relentless in his determination to meet our production scales with full stocks of A.I.D. Released components. This is an important position and carries an adequate salary. Please write to:— The Chief Buyer, Microcell Ltd., 56 Kingsway, London, W.C.2. W 3716

A. V. ROE & CO. LTD., have vacancies in their Computor Group at Greengate, Middleton, providing opportunities to graduate to be in at the beginning of a new development which is becoming of increasing importance in both scientific and commercial businesses. The most up-to-date computor equipment has recently been installed with the main object of applying it to aircraft design and associated problems. Technicians are required who possess a Degree in Physics or Electrical Engineering for work on the development of Electronic Computing Equipment for use in the Design Office. The Electronics Department is expanding and is likely to take in many diverse fields of development. Preference will be given to applicants who have some practical experience. Applications stating full details of age, qualifications and experience should be addressed to the Labour Manager, A. V. Roe & Co. Limited, Greengates, Middleton, Manchester. W 3640

A YOUNG MAN, 21 to 28 years of age, is required by a large old-established Company with Works in the North Midlands area to assist in development work on small components for the electronic industry. Some experience in the radio or electronic industry would be an advantage. Applicants should be of Inter. Degree standard or possess an equivalent qualification, and should be interested in experimental work. The position is to the permanent staff of the company and carries superannuation rights. Salary will be in accordance with age and experience. Write giving full personal details, to the Secretary, Johnson, Matthey & Co. Limited, 78 Hatton Garden, London, E.C.1. W 3765

BUSH RADIO LTD. have a number of vacancies in their Design Laboratories in London and Plymouth, for work in the following fields:— TV, Colour TV, U.H.F., V.H.F., F.M., Transistor Applications, and interesting Government contracts, including pulse and microwave techniques. Applications for these vacancies are invited from:— (1) Senior Development Engineers with B.Sc., Degree or equivalent qualification, and several years' experience of design and engineering development for eventual productions. (2) Engineers and Physicists with good qualifications but limited practical experience. (3) Development Engineer with three to five years' practical experience in the design of radio or television receiver or circuits. (4) Laboratory Assistants to carry out experimental work under guidance from seniors. The positions offered are permanent, pensionable and progressive. Housing assistance may be arranged in approved cases. Reply, in first instance, with full details of qualifications, experience and salary required, quoting Ref. ENG/PCK.1 to the Personnel Manager, Bush Radio Ltd., Power Road, London. W.4. W 3745

DESIGN DRAUGHTSMAN. Senior vacancy exists in the laboratory of an engineering company for a good design draughtsman with experience of T.V. and/or electronic services equipment. This vacancy offers excellent opportunities for advancement and a good commencing salary will be paid to the accepted applicant. Superannuation scheme available. London area. Please reply, giving full details to Box No. W 3736.

CHIEF DEVELOPMENT ENGINEER is required to take complete control of all design and development activities. Must have had Production and Drawing Office experience and possess qualifications enabling him to cover Electrical Measuring Instruments. Electro-Mechanical and Electronic devices. Relays, etc. This is a very important permanent and pensionable position. Applications in complete confidence, with details of age, qualifications and salary expected, should be made to Mr. J. P. Steward, Measuring Instruments (Pullin) Ltd., Electrin Works, Winchester Street, Acton, W.C.3. W 3709

DESIGN/ENGINEER - DESIGN DRAUGHTSMAN. Are your weapons of education and practical experience, forged with hard work and scholarship rusty from disuse? Although with Dickens, we believe that "genius is an infinite capacity for taking pains", we do not aspire to an embryo Baird, although he would be very welcome! We are Prosaic enough to think that somewhere, there are young men anxious to apply their talents in the light engineering or radio field, so that they are not buried, but used for the common good. Men, over 30, are invited to write to:— The Chief Engineer, Pye Limited, Radio Works, Cambridge. W 3727

DESIGNER OF MAGNETIC recording equipment required for the Domestic Electronics Division of E.M.I. Ltd. A number of interesting projects are in hand giving scope for inventive ability to applicants who have knowledge of electrical circuitry and who are interested in small mechanisms. The vacancy is in the Laboratory at Greenford and salary will be commensurate with ability. Write in the first instance, giving fullest details of education and experience, to Personnel Department/CLR, E.M.I., Hayes, Middlesex. W 3721

DEVELOPMENT ENGINEER REQUIRED for circuit design of electronic instruments. Applications include equipment for acoustic, ultrasonic and industrial measurement and control. Permanent position in an expanding organization. Experience or suitable technical qualifications essential. Apply giving full details of experience, qualifications, age and salary desired to Chief Development Engineer, Dawe Instruments Ltd., 99 Uxbridge Road, Ealing, W.5. W 3744

DEVELOPMENT ENGINEER OR PHYSICIST. Solus Electronic Tubes Ltd., 15-18 Clipstone Street, W.1, makers of X-ray tubes and valves, need young qualified physicist or engineer experienced in vacuum work, for expanding allied developments. Experienced technical assistants also considered. W 1461

DEVELOPMENT ENGINEERS and Physicists. Applications are invited from Development Engineers and Physicists to fill a vacancy in the laboratories of Louis Newmark Ltd., for work on the development of electromagnetic devices principally for incorporation in aircraft instruments and equipment. A Degree or similar qualification is considered essential, and some previous laboratory or engineering industrial experience in any field desirable. The position carries considerable responsibility and offers plenty of opportunity for advancement. Applicants should be of British nationality. Pension Scheme. Please apply in writing giving full particulars to: Personnel Officer, Louis Newmark Ltd., Prefect Works, Purley Way, Croydon. W 3754

DEVELOPMENT ENGINEERS required for work on nucleonic and allied instruments. Qualifications: Ordinary National Certificate or equivalent. Previous experience in pulse techniques preferred but not essential. Salary: £7 5s. to £14 per week according to age, experience and ability. Apply: Secretary, Isotope Developments Ltd., Beenham Grange, Aldermaston Wharf, Berks. W 3718

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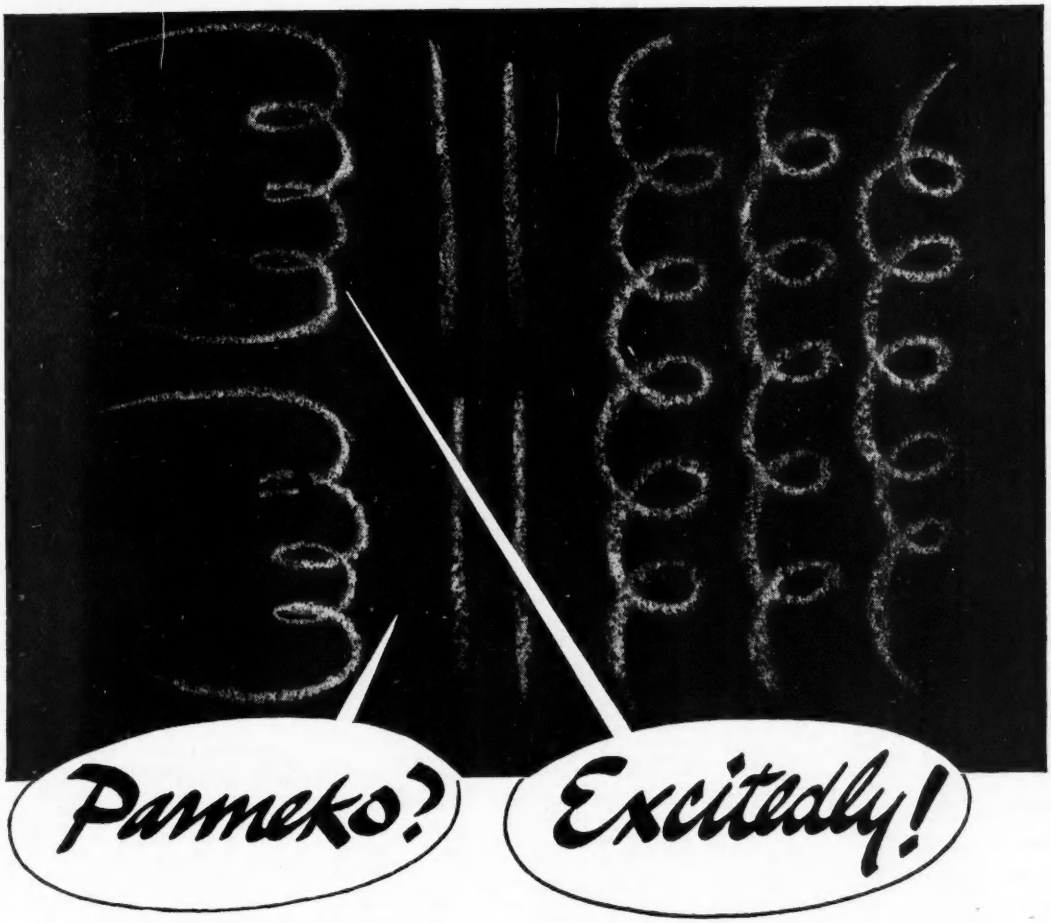

Are you the auto-excited type, old boy ?

Very, George. I remember a straight-eight I used to have, with four synchronised carburettors and temperamental brakes, that once . . . .

No, no—what I mean is, are your rectifiers connected in series with the ouptut winding so that the output current automatically saturates the transductor . . . . . .

Where do you get all this ' output ' on transductors, George ?

From a Parmeko leaflet—it tells me that they have a standard range of 14 types for operation at supply frequencies of 400 and 1600 cycles and some for 50 cps.

Sounds very varied.

They are indeed—they're being used in magnetic amplifiers all over the place.

Do you think I could get one of these leaflets of theirs ?

Yours for the asking, George. They're in Two Colours and Fully Illustrated, as they say . . .

PARMEKO *of* **LEICESTER**

MAKERS OF TRANSFORMERS FOR THE ELECTRONIC AND ELECTRICAL INDUSTRY

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

DEVELOPMENT ENGINEERS and Technicians required in research department of a well-known firm of Precision Engineers, particularly for work in connexion with Servo Systems, Small Precision Motors, and Gyroscopic Instruments. Apply stating age, experience and salary required to S. G. Brown Ltd., Shakespeare Street, Watford, Herts. W 220

DEVELOPMENT ENGINEER required for the basic circuit investigation in nucleonic instrument field. Previous work in this field not necessary but experience of pulse techniques essential. Minimum qualifications: Degree in electrical engineering or equivalent. Age 23/28. Salary £500-£700 per annum. Apply: Secretary, Isotope Developments Ltd., Beenham Grange, Aldermaston Wharf, Berks. W 3719

DEVELOPMENT STAFF OF SENIOR and Junior status are required by J. Langham-Thompson Ltd., 88 High Road, Bushey Heath, Herts. The Company invites applicants, for a new and expanding laboratory in the Stanmore area, North London, in the following capacities: (a) Electronic Engineers, (b) Electronic or Mechanical Draughtsmen, (c) Test Engineers; to work in the following fields: (A) Circuit design, (B) UHF and Microwave communications, (C) Mechanical and allied servo systems. The posts offer ample scope for initiative and promotion by ability. Apply in writing to the Chief Engineer, stating age and full details of experience. W 3759

DRAUGHTSMEN: Vacancies for senior Draughtsmen with experience of Electronic and/or Electro-mechanical engineering required, preferably with experience of Ministry requirements. Excellent prospects with good commencing salaries; non-contributory Pension Scheme in operation. Applications will be treated in strict confidence and should give full chronological details of qualifications, experience and age to: John A. Smith Ltd., 24 Lichfield Street, Wolverhampton. W 201

ELECTRICAL OR ELECTRONIC ENGINEER required by progressive Engineering Company in Gloucestershire. Degree standard or equivalent. Interesting development work on induction heating and other projects. Apply Box No. W 3750.

ELECTRONIC DEVELOPMENT ENGINEERS wanted for the design and development of Test Equipment for a North London Company. Salary commensurate with experience, opportunity for advancement, pension scheme, etc. Write giving full particulars of experience and salary required to Newspaper Box No. W 3704.

ELECTRONIC ENGINEER. A young graduate in electrical engineering or physics with an interest in electronics is required by the Plessey Company to carry out the design of electronic scintillation counters. Initially the candidate will be under the supervision of a senior engineer but will be expected to require a minimum of supervision. The work involves the use of latest techniques in this field and gives considerable opportunity for original work. A commencing salary of up to £700 per annum is considered, depending upon age, qualifications and experience. Applications, in writing, should be addressed to the Personnel Manager, The Plessey Company Ltd., Ilford, Essex. W 3723

ELECTRONIC ENGINEERS (22-26 years) required as Assistant Project Engineers. Applicants should possess O.N.C. or equivalent and have experience in laboratory work. A knowledge of Production Engineering and experience on Radar Equipment in H.M. Forces would be an asset. These vacancies offer much scope for persons with drive and initiative. Apply to the Personnel Officer, Decca Radar Ltd., 1 Tolworth Rise, Surbiton, Surrey. W 3712

ELECTRONIC INSTRUMENTS LTD., Lower Mortlake Road, Richmond, require Laboratory Assistants for circuit development, prototype building, etc. Minimum qualifications Higher National Certificate. Write full details in confidence to Production Manager. W 1444

ELECTRONICS ENGINEER B.Sc. or H.N.C. for laboratory development work on miniature equipment using transistors. Work in Slough/Marlow area. Five-day week, canteen, pension scheme. Wide scope for energetic versatile man with progressive ideas. Full details of age, experience, salary required to Box W 3730.

ELECTRONIC ENGINEER.—Degree or equivalent, practical design experience of V.H.F. Transmitters and Receivers essential. Small but rapidly expanding organisation on South Coast. Near Southampton. Write full details, age, experience and salary expected. Box No. W 303

ELECTRONIC ENGINEERS required for work on the application of Radio Valves for future Development. Work calls for vision and imagination combined with circuit experience. O.N.C. or Inter. minimum qualifications. Weekly or monthly staff vacancies available according to experience. Quote EE/3, Personnel Dept., M.O. Valve Co. Ltd., Brook Green, Hammersmith, W.6. W 3531

E.M.I. ENGINEERING DEVELOPMENT LTD., Experienced Valve Engineer. An interesting vacancy has arisen at the Company's Feltham Laboratories for a Valve Engineer with 4-6 years' experience of both valves and microwave generators. Applicants who should be qualified, will have some knowledge of testing both in quantity, and for special purposes, will be able to design suitable test equipment, and have some applications experience. The salary offered for this pensionable post is attractive, and the prospects in this active Company are excellent. Please address your first reply to Personnel Dept. (ED/252), E.M.I. Eng. Dev. Ltd., Blyth Road, Hayes, Middlesex. W 3714

E.M.I. ENGINEERING DEVELOPMENT LTD. A vacancy exists for an Electronic Engineer to undertake inter-company liaison duties in connexion with the distribution and design of Telemetry Equipment. A wide experience of electronic engineering including V.H.F. techniques is essential. Experience of Telemetry equipment and ability as a Technical Writer would be an advantage. Please write with full details to Personnel Dept. (ED/266), E.M.I. Eng. Dev. Ltd., Hayes, Middlesex. W 3766

ENGINEERS (Radio Valves) are required for all grades of work on Development, production and pre-production: Experience necessary for senior appointments. No previous experience needed for the Junior Posts but O.N.C. or B.Sc. (Inter.) minimum qualification. TA/8 Personnel Dept., M.O. Valve Co. Ltd., Brook Green, Hammersmith, W.6. W 3532

ENGINEERS required for applications development into the use of transistors for communication engineering circuits and components. The vacancies occur due to expansion in the laboratory of a self-contained unit of a large engineering company located in the eastern London area To the successful candidates there will be every opportunity for advancement and a good commencing salary will be paid. Please reply, giving full details of qualifications and experience to Box W 3780.

EXPANDING ELECTRONIC DIVISION of a Company of established reputation requires able and experienced Senior Electronic Engineers to undertake a responsible part in the development of a wide variety of specialized equipment. The appointments are permanent and pensionable. Attractive salaries are offered to engineers capable of directing entire projects with initiative and enthusiasm. Candidates should preferably possess an Honours Degree or the equivalent, although a lack of academic qualifications should not serve as a deterrent to engineers of proven ability. Experience should include several years of circuit design, and a sound knowledge of radio communications circuits is an advantage. Applications will be treated as confidential and should be made to The Superintendent, Electronic Development Division, R. B. Pullin & Company Limited, Great West Road, Brentford, Middlesex. W 311

ENGINEERS REQUIRED for advanced application development for colour television with particular reference to receiver and receiver component parts. Degree preferred but not essential. Excellent salary to the selected applicants. London area. Please reply, giving full details to Box No. W 3782.

ENGLISH ELECTRIC VALVE COMPANY, Chelmsford, require Microwave Engineers and Physicists for development work on Magnetrons, Travelling Wave Tubes, Klystrons, Image Orthicons and allied devices. Applicants should preferably be Graduated but others with sufficient practical experience will also be considered. Apply to Dept. C.P.S., 336/7 Strand, W.C.2, quoting ref. 497N. W 3726

ERICSSON TELEPHONES LTD. have in their Research Laboratories a number of vacancies for circuit designers and equipment engineers to work on nucleonic instruments, and interesting new developments in electronic computing and switching; both senior and junior posts are available. Applicants should have a degree or equivalent plus several years' experience of appropriate work for the senior posts; correspondingly reduced qualifications and experience will be accepted for junior posts. Salaries will be in accordance with age, qualifications and experience. Applications, giving details of age, academic or other training and qualifications, experience, and starting salary required, should be sent to the Personnel Officer, Ericsson Telephones Ltd., Beeston, Nottingham. W 197

EXPERIMENTAL ELECTRONICS ENGINEER required for leading scientific instrument manufacturer to head a group engaged on the development of nuclear magnetic resonance spectrometers. Commencing salary £850 to £1,100 per annum according to qualifications. Pension scheme. This is an interesting opportunity in a company having a world wide reputation in the scientific instrument field. Write, stating age and full details to Box W 3651.

EXPERIENCED Radio Testers and Inspectors required for production of communication and radio apparatus. Also Instrument makers, wirer and assemblers for Factory Test apparatus. Apply Personnel Manager, E. K. Cole Ltd., Ekco Works, Malmesbury, Wilts. W 146

FASCINATING WORK IN a small, lively and progressive organization is offered to energetic Electronic Engineers who can produce bright ideas and speedily develop them with a minimum of supervision. Field of operations includes analogue Computors, pulse techniques, flight simulators, application of electronic techniques to problems of physical measurement and numerous unexpected applications of thermionic and semi-conductor circuitry. Acceptable qualifications are Degree or H.N.C. plus at least five years' industrial experience, and highly developed practical ability. If you consider yourself suitable and would like to live in the Isle of Wight (assistance will be given with accommodation) apply now, quoting relevant details and Ref. EE/45 to the Personnel Officer, Saunders-Roe, Limited, East Cowes, I.O.W. W 3676

FIELD SERVICE ENGINEER required for liaison with the R.A.F. The work includes technical duties in connexion with the installation, introduction into service and use of navigational aids. Applicants should be capable of undertaking the servicing of equipment after a suitable training period. Apply in writing giving details of experience to Personnel Department (F.S.E.), Murphy Radio Limited, Welwyn Garden City, Herts. W 3757

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Remember – Remember...

Guy Fawkes discovered that it's not only the size of the bang, but the timing which counts. Dr. Frittertime should have remembered this when he undertook to stage a firework display for the neighbourhood. On the night, an impressive array of home-made pyrotechnics faced the expectant crowd. All went well until the ambitious Doctor attempted to launch two rockets and a Catherine wheel simultaneously, but an ambulance and a couple of fire engines soon had things under control.

Many companies prefer to build their own equipment, but they should remember to consult the catalogues before abandoning themselves to the creative impulse. The Wide Range Oscillator CO 546 is one of many new instruments in our Short Form Catalogue. Offering new facilities, including a wider frequency range, it has replaced the OS 101, but the price remains unchanged. Full details of this or of any other equipment will be sent on request.

BRIEF SPECIFICATION OF THE CO 546

Frequency Range :	25 c/s to 500 Kc/s in five switched ranges. Additional calibration at 300 and 600 Kc/s. Accuracy of calibration ±1% or ± 1 c/s.
Hum Level :	Less than 0.1% of maximum output.
Output Level :	Monitored on meter calibrated 0–10 volts R.M.S. Max. output 100 milliwatts into 600 ohms.
Attenuation :	Built-in 0–60 db attenuator
Dimensions :	22⅛" × 10¼" × 14¼" deep.
Weight :	53 lbs

THE SOLARTRON ELECTRONIC GROUP LTD.

RELIABILITY—UNDER OUR 12 MONTHS' GUARANTEE, COSTS HAVE NEVER EXCEEDED 0.2% OF SALES

Thames Ditton, Surrey
Telephone : EMBerbrook 5522
Cables : Solartron, Thames Ditton

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

FERRANTI LTD., Wythenshawe, have a number of vacancies for (1) Engineers and Physicists for Research and Development work in the following fields:— Radar, radio and electronic circuits. Microwave systems. Hydraulic control systems and servo-mechanisms. Relays and Electromechanical Devices. Test equipment associated with the above. Applicants should be graduates in Electrical or Mechanical Engineering or Physics, or hold equivalent qualifications. For these vacancies some previous experience is desirable. Salary range £800-£1,500. (2) Technical Assistants, possessing Degrees or Higher National Certificates in Electrical or Mechanical Engineering or Physics for experimental work in the fields listed in (1). Salary range £600-£900. for Honours Graduates or £500-£800 for lesser qualifications according to experience. The appointments would be to the permanent staff of the Company and offer the prospect of interesting work in Modern, Well-Equipped Laboratories in South Manchester within easy reach of Residential Districts. The Company operates a Staff Pension Scheme. Application forms from Mr. T. J. Lunt, Staff Manager, Ferranti Ltd., Hollinwood, Lancs. Please quote reference W (1) or (2). W 3485

FIRST-CLASS DESIGNER Draughtsman required by a Company specializing in industrial electronic controls to work on the design and development of a wide variety of interesting mechanisms and machines. Must be a practical man preferably possessing H.N.C. or equivalent and prepared to carry out experimental work. Possibility of successful applicant taking complete charge of drawing office and all mechanical design and directly responsible to Chief Engineer. Above all must be first-class man to whom a first-class salary will be paid. Box No. W 1465.

GRADUATE ELECTRICAL DEVELOPMENT Engineers are required by the British associate company of the international Hispano Suiza group for interesting and varied work on electronic and electromechanical equipment. Initiative and ability to learn are of more importance than detailed experience of similar work. The company, which exports a considerable part of its output, maintains close relations with its European associates and although expanding, can still offer promising opportunities to young men of ability who do not wish to become a cog in a vast machine. Appointments are permanent and entitle holders to participation in our superannuation scheme. Applications with details of age, qualifications, experience and salary required to British Manufacture and Research Co. Ltd., Grantham, Lincs, quoting ref. AWK/Staff/EE. W 1437

GUIDED WEAPONS. Avimo Ltd., Taunton, Somerset. Required a Leader for the design, development and production department. The position is a senior executive appointment carrying considerable responsibility and will be remunerated accordingly. The successful candidate will be an Electronic Engineer under 40 with the necessary knowledge, experience and energy not only to lead his own team, but also to take an active part in all aspects of the work connected with the Company's Electronic Division. As the Company is expanding the opportunities for future advancement are excellent for the right type of man. Pension Scheme and assistance given in providing housing accommodation. Application giving the fullest possible information should be addressed to: Managing Director, Messrs. Steer-Webster & Partners Ltd., 94 Park Lane, London, W.1. W 1452

FIRST-CLASS ELECTRONIC ENGINEER required to work on the design and subsequent development of a wide variety of both large and small electronic projects for industry. Must be a practical man with H.N.C. or equivalent experience. Knowledge and interest in Physics would be an advantage. Above all must be first-class man to whom a first-class salary will be paid. Box No. W 1464.

GRADUATE PHYSICISTS and electrical engineers required for the development of practical applications of new materials and products including transistors, semi-conductor devices, non-linear dielectrics, magnetic materials, etc. The posts involve working in close contact with teams dealing with the development and fundamental properties of the materials. Some experience in the field of solid state physics, radio communication engineering or electronic engineering is desirable. Location Northants. W 3707

GRAVINER AIRBORNE FIRE Protection Equipment. Development Engineers and Technical Assistants for design and development of an interesting variety of aircraft components comprising Equipment for Aircraft Fire Protection, for the Suppression of Explosions in Aircraft and for associated projects of a similar nature, Applicants must have experience in development work in the field of Light Electrical/Electronic Engineering. Qualifications should be a Degree or equivalent for the posts of Development Engineer H.N.C. or equivalent for the posts of Technical Assistant. The positions offer good salaries with Pension Scheme, prospects and excellent working conditions in a medium-size factory situated in open country adjacent to the company's sports field. Canteen facilities. Apply in writing in the first instance to:— Chief Development Engineer, Poyle Mill Works, Colnbrook, Bucks. W 1430

INTERNATIONAL BUSINESS MACHINES CORPORATION will establish a new laboratory in Zurich, Switzerland, early in 1956 and wishes to recruit a number of outstanding Electronic Engineers and/or Physicists. Men with actual experience in one or more of the following fields are needed: Electronic Computors Pulse Transistor or Relay circuits. Circuits using ferromagnetic or ferroelectric materials. It is expected that those applying will be capable of developing their own original thoughts and ideas. Apply with full details of qualifications and experience: I.B.M. Research Laboratory, 25 Genferstrasse, Zurich, Switzerland. W 3752

MAJOR INDUSTRIAL ORGANIZATION, setting up Research and Development Laboratories in the Birmingham area, has vacancies for qualified Electronic Engineers to work on electronic and relay switching and sequencing circuits, transistor applications and magnetic amplifiers. Experience in one or more of the above fields is desirable but not essential. The age range is 25-35 years of age and starting salaries in the range £700 to £1,300 per annum. Successful candidates will be expected to join the organization's contributory superannuation scheme. Reasonable removal expenses will be paid. Write to Box No. W 3742.

MULLARD RESEARCH LABORATORIES require Physicists and Engineers of Honours Degree Standard or above, and Technical Assistants of National Certificate standard or above, for research and development work on semi-conductor applications, including transistors, diodes and photocells. The applications cover a wide range of interests in the field of linear amplification and in the non-linear switching field. The type of work varies from fundamental research associated with new devices to development work associated with production devices. The application group is being continuously expanded and there are good opportunities for advancement to more senior positions. Initially, the work will be centred at the Research Laboratories at Salfords. Applicants need have no experience of semi-conductors although such experience will be an advantage. Salaries are based on qualifications, experience and age, and are in keeping with present-day levels. General prospects within the organisation are excellent. Applications to Mr. G. A. Taylor, Personnel Officer, Mullard Research Laboratories, Cross Oak Lane, Salfords, near Redhill, Surrey, quoting reference ERL(W). W 3635

McMICHAEL RADIO LTD., Slough, Bucks, have vacancies from time to time for Electronic Engineers to be engaged on Government projects. Those wishing to be considered are invited to write fully to the Chief Engineer, Equipment Division. W 205

METROPOLITAN-VICKERS ELECTRICAL Co Ltd. Engineers and Draughtsmen. Excellent opportunities for keen and enthusiastic men to join a department associated with radio and machine frequency, resistance, heating development, and application problems. These posts are permanent and pensionable, and as the department is expanding there is every opportunity for advancement. Whilst the experience given below is desirable, every assistance will be given to qualified men wishing to enter a new field. Engineers for development and design of radio frequency generators. A full electrical engineering apprenticeship and experience in high power R.F. equipment essential. Engineers for development and design of mechanical handling equipment associated with radio and machine frequency heating applications. A full electrical and mechanical engineering apprenticeship essential, together with some experience in design of mechanical handling equipment including pneumatics and hydraulics. A Degree or H.N.C. is essential for the above posts. Technical Assistants and Junior Engineers for experimental laboratory work on problems related to the application of radio machine frequencies, and resistance heating. Candidates must have had a full-time electrical or mechanical apprenticeship, and reached at least O.N.C. standard. Draughtsmen, Seniors and Juniors for circuitry layouts, mechanical and electrical equipment associated with radio machine frequency and resistance heating applications. Candidates must have had a full electrical or mechanical apprenticeship, and have O.N.C. or H.N.C. in mechanical or electrical engineering. Write for application form to: The Personnel Manager, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester 17, quoting reference 'B.3.' W 3571

OPPORTUNITIES IN THE United States for English-trained Electronics Engineers. The Engineering Department, Electronics Division of Westinghouse Electric Corporation have available a number of attractive situations. Applicants must have professional standing in the Institute of Electrical Engineers or equivalent standing in the Institute of Radio Engineers. Applicants for these positions should be over 25 years of age with at least three years' experience in design or development in one or more of the following fields. Circuitry, Ground Radar, Communications, Computors, Filters, Antennas, Microwave Cavities and Plumbing, Missile Guidance Equipment, Navigation Aids. Plant is located in the outskirts of Baltimore, Maryland in the beautiful Chesapeake Bay area, with splendid facilities for fishing and sailing. The mountains are but an hour and a half's drive away. Modern centrally heated flats in suburban surroundings are readily available. Many opportunities for advanced education and for cultural pursuits are available in the Baltimore area. Generous relocation allowance is provided to help defray engineers' and their dependents' travel and shipping expenses. To arrange for an interview, send resumé of education, experience and your telephone number to Department E, Westinghouse Electric International Company, 1-3 Regent Street, S.W.1. All replies will be treated as confidential. W 3652

PULSE ENGINEERS. The Plessey Company Limited has two vacancies for engineers with experience in pulse techniques for the testing of an electric digital computor. Training will be given to suitable applicants who will then be expected to use considerable initiative. Previous experience with digital computors, radar or advanced television testing is desirable. Subsequent further promotion will be encouraged to join design teams concerned with the design of future projects in this field. A commencing salary in the range of £750 to £900 per annum is envisaged and will depend upon previous experience and qualifications. Applications in writing should be addressed to the Personnel Manager, The Plessey Company Limited, Ilford, Essex. W 3722

CLASSIFIED ANNOUNCEMENTS
continued on page 10

FORMER troubles disappear with Tufnol

You'll find Tufnol tube makes the best coil formers.
Tufnol is a high-grade electrical insulator. Won't rot or corrode.
Strong and durable wherever you put it to work . . .
yet exceptionally light in weight.
Tufnol coil formers or other components can be machined or moulded to your specification at our factory. Or Tufnol can be supplied for you to machine in your own workshop.

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312

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

PHYSICIST OR ELECTRICAL ENGINEER required by E.M.I. Research Laboratories Ltd., for advanced development work at Hayes on an interesting project concerned with television systems conversion. Qualifications normally required of applicants are a Degree in Physics or Electrical Engineering, or A.M.I.E.E., but an unqualified engineer having exceptional experience will be considered. A knowledge of one of the following fields is required: Television techniques, such as Cathode-Ray Tube, pickup tube and pulse circuitry; amplifiers, phase measurement, and electronic, or magnetic storage. The position is pensionable and offers a good starting salary. Please write full details to the Personnel Dept. (RL/25), E.M.I. Research Laboratories Ltd., Hayes, Middlesex. W 3715

PHYSICIST. A young male graduate in physics is required for research on insulating materials and processes. An interesting and progressive appointment is offered with a prominent East London Company. Write giving full particulars of qualifications and past experience to Personnel Officer. Box W 3720.

PRODUCTION ENGINEER required in connection with the manufacture of Filters for Carrier Telephone Equipment. Positive experience in the control of all aspects of fitter production, including testing, is essential. A technical qualification (H.N.C. or equivalent) would be an advantage. Write fully giving details regarding age, training, experience and salary required to Newspaper Box No. W 3684.

RADIO VALVE ENGINEERS required for Senior positions on Development with London Company. Experience on this type of work essential. Starting salary ranging from £750 to £1,000 according to ability. Apply Box No. W 3529.

RADAR DEVELOPMENT. Senior and intermediate Engineers required for Research Laboratories situated at Dunmow, Essex. The work is of an interesting and varied nature concerning sea and air navigational projects and involves occasional trials under operational conditions. Recent experience in a similar or associated field of electronics is required, together with a technical background, preferably of at least Higher National Certificate standard. Salaries are in accordance with experience and qualifications but are based on generous scales. The positions are permanent and favourable pension and payment during illness arrangements, etc., are in operation. There is ample scope within an expanding organization for personnel who are progressive and able to use their own initiative. Applications, which can be made in strict confidence, should include details of age, qualifications, experience and salary required and be addressed to The Personnel Manager, Kelvin & Hughes Ltd., New North Road, Barkingside, Essex. W 3710

RECORDED SOUND LTD., Marble Arch, requires Electronic Engineer of City and Guilds or Higher National standard. Must have good education and initiative. Good prospects. Starting salary £700 p.a. Apply 27 Bryanston Street, W.1. W 1459

SENIOR MECHANICAL ASSISTANT wanted with first-class experience in design and development record players and changers. Salary in region £2,000 p.a. to man with right ability and experience. Give full details age, education and last seven years' employment and experience, in confidence to Box 1442.

SENIOR TELEVISION DEVELOPMENT Engineer with administrative experience required. Capable of carrying out development projects with minimum supervision up to production stage. Kingston area. Write giving full personal details stating salary required. Chief Engineer. Box No. W 306.

SEMI-CONDUCTORS. The Mullard Radio Valve Co. Limited, has a number of additional technical openings for work on semi-conductor development and engineering for both Graduate Physicists and Chemists. The vacancies for physicists are on device development and pilot manufacture and require an aptitude for experimental work. Industrial Chemists are required for development and engineering of semi-conductor manufacturing processes. These appointments will initially be at the Company's Mitcham Plant, but the successful candidates will be required later to transfer to a new establishment at Southampton. The commencing salaries will be according to individual age, experience and qualifications and can be considered as progressive. Please apply in writing to the Personnel Officer, The Mullard Radio Valve Co. Ltd., New Road, Mitcham Junction, Surrey, quoting reference GBK/S. W 3711

SENIOR DESIGN DRAUGHTSMEN. Four Senior and eight intermediate designer draughtsmen are required for original work on mechanical development in an expanding department. The work is varied in scope but deals with high precision techniques applied to mechanical and electro-mechanical mechanisms for computors, automation equipment, guided missile and atomic energy projects. Experience in the above fields is desirable but not essential. A keen and lively interest in this field is of equal importance to previous experience. Salaries range from £750 to £1,200 p.a. according to experience and qualifications, and promotion will depend solely on ability shown. Please reply, giving full details to Box No. W 3737.

SENIOR DRAUGHTSMEN. Due to expansion of the Electronics Division of The Plessey Company Limited there are several vacancies for experienced men in the following fields: 1. Design of a wide range of electronic equipment, including work to Service requirements. 2. Mechanical design of precision mechanisms for quantity production. These vacancies carry attractive salaries and long-term prospects in reward for hard work and offer good staff conditions including superannuation and insurance schemes. Applications, which will be treated in confidence, should be addressed to: The Plessey Company Limited, Vicarage Lane, Ilford, Essex. W 3760

SENIOR ENGINEERS required by Philco for Radio and Television Development. Men with several years' experience of design for quantity production are invited to discuss the possibility of joining an engineering team working under congenial conditions in a go-ahead organization. Permanent staff appointments at progressive salaries are offered, and there is a pension scheme. Write or phone Chief Engineer for an appointment Philco (Overseas) Ltd., Romford Road, Chigwell, Essex. Phone Hainault 4151. W 1463

TECHNOGRAPH ELECTRONIC PRODUCTS Ltd., require junior draughtsmen with electrical or electronic experience, for preparation of master and engineering drawings. Prepared to work in London for a few months, later in Hampshire. Write in first instance giving full details of education, experience and salary required to 32 Shaftesbury Avenue, W.1. W 1450

SOLARTRON TECHNICAL - COMMERCIAL applications engineers. Men with Degree H.N.C. or equivalent knowledge of electronics or physics, and also ability to write technical reports, offered excellent opportunity for studying applications of electronic and electromechanical equipment. Please write to The Personnel Director, Solartron Electronic Group Ltd., Queen's Road, Thames Ditton, Surrey. W 3769

SMITHS AIRCRAFT INSTRUMENTS Limited, Bishops Cleeves, near Cheltenham, Glos, have vacancies in their Guided Weapons Research Laboratories for Engineers for work on the Design and Development and short-order Production Engineering of:— (1) Electronic Control and Navigation Systems. (2) Precision electro-mechanical components including gyroscopes, pick-offs, accelerometers and small motors. (3) Hydraulic servomechanisms including the detailed design and development of hydraulic components. (4) Associated Test Equipment. Qualifications required are either Degree in Electrical or Mechanical Engineering or Physics, or H.N.C. in Electrical or Mechanical Engineering or equivalent qualifications. For the more senior vacancies, considerable experience in one or other of these fields is necessary, whilst for other vacancies some such experience is desirable. Salaries will be on a generous scale appropriate to qualifications and experience. These are progressive positions in a new and expanding organization situated in a rural area and working conditions in these modern laboratories are ideal. A voluntary contributory Pension Scheme is in operation and canteen, transport and recreational facilities are available. Write, in first instance, for application form to:— Personnel Manager, Smiths Aircraft Instruments Ltd., Bishops Cleeve, near Cheltenham, Glos. Quoting ref.: G.W./10. W 3670

TEST ENGINEER for nucleonic equipment. Applicants should have knowledge to C. and G. Radio II Standard. Apply: Secretary, Isotope Developments Ltd., Beenham Grange, Aldermaston Wharf, Berks. Tel. No. Woolhampton 451. W 3717

TECHNICAL ASSISTANT. An interesting opportunity occurs for a Technical Assistant in the Analogue Computing Section. Applicants must possess H.N.C. (Elect.) or equivalent with basic knowledge of electronics and be interested in the solution of problems associated with aircraft engineering. This post is permanent in N.W. London area and carries generous salary with attractive working conditions. Apply in confidence: Box A.C.13473, Samson Clark's, 57-61 Mortimer Street, London, W.1. W 3746

TECHNICAL ASSISTANT required for radio-receiving valve manufacture. Experience desirable but training given. Minimum qualification O.N.C. Inter. B.Sc. Write giving age and details of experience to reference SM/W. Personnel Office, M.O. Valve Co. Ltd., Hammersmith, W.6. W 3732

TECHNICAL SALES ENGINEER required with knowledge of Polarized Relays and their applications or a good knowledge of Telecommunications. The position offers wide scope in an expanding sales organization for a keen engineer of good appearance. Applicants should possess H.N.C. or similar qualifications and write giving full details of experience to date in chronological order and salary required to the Personnel Manager, Telephone Manufacturing Co. Ltd., Martell Road, West Dulwich, London, S.E.21. W 3708

THE BRUSH ELECTRICAL Engineering Co., Ltd., requires an Electronics Engineer or Physicist to join a newly-formed and rapidly-expanding Research and Development Group. It is desirable that previous experience should include University or Industrial Research in Electronics or Servo Mechanisms. An attractive salary will be offered to a suitable candidate, and there will be excellent opportunities for advancement. The successful applicant will work under most desirable conditions in the new Research Laboratories of a factory situated in a pleasant country area. There are generous terms of service, including a non-contributory superannuation scheme. In the first instance applicants should send a brief statement of their experience to Dr. D. R. Hardy, Chief Research Engineer, Brush Electrical Co., Ltd., Loughborough, Leics. W 3790

CLASSIFIED ANNOUNCEMENTS
continued on page 12

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

TECHNICAL WRITER. A vacancy exists for a Technical Writer knowledgeable in electronics, for the preparation of instruction books and descriptive technical literature. Applicants should have a flair for writing and technical qualifications equivalent to Higher National Certificate. Previous experience, whilst desirable, is not essential. Applications stating age, and giving particulars of qualifications and experience to Manager, Electronics Engineering Department, British Thomson-Houston Co. Ltd., Rugby. W 3758

TECHNICAL WRITER required for Publicity Department of large West London firm of Electrical Instrument and Instrumentation and Control Equipment manufacturers. Work will comprise helping to prepare instruction books, catalogues, press articles and articles for house journal. Wide technical knowledge desirable, particularly of electrical equipment. Evidence of writing ability will be required. Write, giving details of qualifications, experience and salary required, to: Box No. W 1455.

TECHNICAL WRITER to Produce technical bulletins and operating instructions (with minimum supervision) dealing with Picture Telegraph equipment, measuring instruments, magslip and servo components. Degree or H.N.C. desirable with aptitude for this specialized form of writing. Pension Scheme, canteen, excellent working conditions. Apply in writing to Muirhead & Co. Ltd., Beckenham, Kent. W 3738

THE EDISON SWAN ELECTRIC Co., Ltd., Cosmos Works, Brimsdown, Enfield, Middlesex, has vacancies in its Research and Development Departments for: 1. Development Engineers for work on design and development of thermionic valves. 2. Technical Assistants for work in connexion with design and development of thermionic valves. 3. Mechanical Engineers interested in the problems of mass production associated with thermionic valves. These vacancies are the result of a rapid expansion in the Company's activities. The positions are progressive and carry the advantages of a Pension Scheme. Applicants for vacancies (1) should have an Engineering or Physics Degree, but applications from candidates with H.N.C. or equivalent will be considered. Applicants for vacancies (2) and (3) should have Ordinary N.C. or H.N.C. or Inter. B.Sc., or equivalent. The starting salary will be in accordance with the qualifications, experience and age of the applicants. Applications should be in writing and will be treated with the strictest confidence. Apply to the Personnel Superintendent. W 3657

THE GENERAL ELECTRIC CO. LTD., Brown's Lane, Allesley, Coventry, requires Mechanical Development Engineers, Designer-Draughtsmen and Draughtsmen, preferably with experience of Radar type equipments for work on Guided Weapons and like projects. Also required, Senior and Junior Electronic Development Engineers, particularly in the field of Microwave and Pulse Applications. Salary according to age, qualifications and experience. Apply by letter stating age and experience to the Personnel Manager. Ref. R.G. W 208

THE INDEPENDENT TELEVISION Authority invites applications for the post of Transmitter and Aerial Engineer in its Headquarters establishment. Applicants should be fully qualified professional engineers with first-class technical knowledge and practical experience of the specification, design, constructional technique, installation and testing of high power V.H.F. vision and sound transmitters and preferably also of television transmitting aerials and their associated transmission line systems. Some experience in the siting and overall planning of complete transmitting stations would be a great advantage. The salary will be in the neighbourhood of £1,800 per annum but may be somewhat more in the case of a man of appropriate calibre. There will be a pension scheme. Applications stating age, qualifications and experience should be sent to the Authority, 14 Princes Gate, London, S.W.7. W 3739

TEST and Laboratory Engineers required for Gyro and Electro Mechanical Instruments. Apply stating age, experience and salary required to S. G. Brown Ltd., Shakespeare Street, Watford, Herts. W 216

THE MULLARD RADIO VALVE CO. LTD., has a number of vacancies for Technical Assistants on the following Divisions at its Mitcham factory: Cathode-Ray Tube Division, Valve Making Division. Semi-Conductor Division. Valve Application and Measurements Division. Gas Discharge Valve and Photo Electric Cell Division. In each field of work vacancies exist in the Production, Development and Technical Departments. Applications are invited from persons holding the General Certificate of Education at Ordinary level in science subjects and at Advanced level, and others who possess either the Ordinary or Higher National Certificate in Electrical Engineering. The posts give an opportunity for further training in the electronics field and there are facilities for further study leading to higher qualifications. There are, in addition considerable opportunities for promotion in varying and expanding fields of electronic work. Commencing salaries will be according to age, experience and qualifications and be considered as progressive. There is a Company Pension Scheme and Long Service Holiday Plan. Applications in writing, which will be treated with the strictest confidence, should be addressed to The Personnel Officer, The Mullard Radio Valve Co. Ltd., New Road, Mitcham Junction, Surrey, quoting reference JFG/TECH/GEN. W 3767

THE MULLARD RADIO Valve Co. Ltd., has vacancies for Development Engineers in its expanding Semi-Conductor Division. The work involves investigations into the properties of semi-conductor devices and pursuing their development. This is a new and expanding field in the electronic industry and as far as possible applicants should be graduates with some electronic experience. In certain cases applicants possessing the Higher National Certificate in Electrical Engineering will be considered. The commencing salary will be according to qualifications and experience. Applications should be addressed to The Personnel Officer, Mullard Radio Valve Co. Ltd., New Road, Mitcham Junction, Surrey, quoting the reference SCD/JFG/SW. W 3753

THE PLESSEY COMPANY has vacancies in its Electronic division laboratories at Ilford for radio and electronic engineers in the following grades: Project Engineers, Senior Engineers, Junior and Assistant Engineers, Senior Draughtsmen. These are NOT temporary vacancies, created by comparatively short-term defence contracts, but permanent posts arising in the course of the continual expansion of the division's engineering activities in the electronic fields. Senior men can be assured of remuneration commensurate with their experience and qualifications, while in the junior grades there are excellent opportunities for training and advancement. There is a considerable range of work available and the earlier applicants will have a wide choice of activities. Write, in confidence, to the Plessey Company Limited, Vicarage Lane, Ilford, Essex. W 3761

ULTRASONIC RESEARCH and Development. There are progressive posts for young physicists or engineers in an expanding department concerned with the application of ultrasonics to non-destructive testing. Energy and ability more important than qualifications but Degree standard desirable. Some electronic aptitude a distinct advantage. Salaries will be paid according to qualifications, experience and ability but are based on generous scales and adequate payment during illness and pension schemes, etc. are in operation. Applications can be made in strict confidence and should include details of education, age and salary required and be addressed to: Personnel Manager, Kelvin & Hughes Limited, New North Road, Barkingside, Essex. W 3755

TRANSFORMER DESIGNER required for expanding Company situated in S.E. London. A wide range of small Transformers of all types is covered including both commercial and Services specifications. A good salary is offered to a person with the right experience and qualification, but younger person with basic training but limited experience would be considered as trainee. Write giving details of qualifications and experience to Box No. W 1453.

ULTRA ELECTRIC LIMITED, Western Avenue, Acton, London, W.3, require the following Engineering Staff for permanent, responsible posts in their expanding organization. Excellent conditions in modern laboratories. Attractive salaries. Pension Scheme. 1. Television Development. (a) Senior Engineers with good academic qualifications and experience in R.F. circuit design or pulse and scanning techniques. (b) Junior Engineers with academic qualifications or development experience. 2. Radio Development. Radio Development Engineers with good academic qualifications and experience. Some experience of AM/FM receiver design an advantage. 3. Electronics. (a) Senior Electronic Engineers capable of handling teams engaged on research and development of: (1) U.H.F. and V.H.F. communication systems. (2) Electronic navigation systems. (3) Development of transistor applications. (4) Industrial application of electronics. (b) Junior Engineers with suitable qualifications and/or experience of work in the above fields. (4) Servo Mechanisms. (a) Senior Engineers for the development of electric servo control equipment for application to aircraft. Knowledge of magnetic amplifier techniques desirable. (b) Junior Engineers to assist in the above work. (c) Laboratory Assistants required with a knowledge of instrumentation and component testing. (5) Test Equipment (a) Development Engineers for design and development of production test equipment for TV, Radio or contract work. H.N.C. standard and experience. (b) Junior Engineers with qualifications and preferably with some experience. (c) Laboratory Assistants for measurements section. Experience of calibration and certification of electronic equipment essential. (6) Mechanical Laboratory. Junior Development Engineers for mechanical test laboratory work. Should have practical training O.N.C. or equivalent qualifications. Drawing Office experience an advantage. Applicants are requested to write to the Personnel Manager (mentioning post desired) and give full details—in confidence—including experience, qualifications, age and salary required. Saturday morning interview arranged if desired. W 1427

WIREMAN for specialized electronic instruments, some theoretical knowledge, Kilburn area. Box No. W 1450.

YOUNG ELECTRONIC ENGINEER required. Must have practical experience and knowledge of transformer design. West London area, State qualifications and salary required. Box No. W 1451.

Further "Situations Vacant" advertisements appear in display style on pages 132, 133, 134, 135, 136 & 137.

SITUATIONS WANTED

A HIGH SALARY is required by a qualified executive engineer. In return for this he will undertake the supervision of senior staff and maintain contact with suppliers and customers. Box No. W 1462.

NO QUALIFICATIONS. Practical experience in servicing A.A. Radar 1941-46: development of amplifiers and electronic apparatus for vibration testing of aircraft, etc., seeking progressive situation. Resident Deal. Box W 1445.

SERVOMECHS. Ministry and industrial contracts. Senior Engineer experienced 15 years in Radio Warfare, telemetering, transmission and control mechanisms. Author and lecturer in electronics, seeks offer. Box No. W 1467.

TRANSFORMER ENGINEER with several years' experience of design and production seeks responsible position. Companies seeking young engineer with experience and foresight in this or allied fields should write full details to Box W 1440.

WANTED

AMERICAN DOLLARS PAID for unused valves! Any type. Any moderate or large quantity. Must be new, in boxes or bulk packaged. Will pay cash or trade for other valves or electronic equipment. Send complete list and details to: Barry, 512 Broadway, New York 12, N.Y., U.S.A. W 1449

COPIES of Electronic Engineering March, April, August, 1955, one shilling each plus postage offered. Box W 313.

EDUCATIONAL

THE POLYTECHNIC, 309 Regent Street, W.1. Electrical Engineering Department. A course of eight lectures will be given on Thursday evenings from 7-8.30 p.m. on Industrial Applications of Servo-Mechanisms, commencing 12th January, 1956. The lecturers will be G. W. Alderton, B.I.S.R.A., J. V. Hughes, Ph.D., F.Inst. P., P. G. Kendall, B.Sc. (Eng.), and L. E. Meeks. A synopsis of the lectures and form of application for enrolment may be obtained from the Head of the Electrical Engineering Department. Fee for the course £1 10s. W 3778

T.V. AND RADIO—A.M.Brit. I.R.E., City & Guilds, R.T.E.B. Certificate, etc., on "No Pass —No Fee" terms. Over 95 per cent successes. Details of Examinations and Home Training Courses in all branches of Radio and T.V. Write for 144-page handbook—Free. B.I.E.T. (Dept. 337H), 29 Wright's Lane, London, W.8. W 187

SERVICE

CAPACITY AVAILABLE for light electronic assembly, wiring, soldering, cableforming, etc., up to 2,000 operator hours weekly. Long or short runs. Competitive prices. Well-known company. Highest credentials A.I.D. Approved. Works situated in Greater London area. Box No. W 1458.

CAPACITY AVAILABLE for wave winding and assembly. Large or small quantities, prompt deliveries, A.I.D. and A.R.B. approved. Avis & Baggs Ltd., Gosbrook Road, Caversham, Reading. Tele. 71763. W 3751

ELECTRONIC ASSEMBLY, machine capacity available. (aid). Bel Marlborough Yard, N.19. ARC 5078. W 219

DESIGN OFFICE CAPACITY available for Mechanical and Production Engineering, Special Machines and Projects. Norris Brothers Ltd., 53 Victoria Street, London, S.W.1. Tel. Abbey 5444. W 1454

ESTABLISHED ELECTRONIC MANUFACTURING Company require additional work of the following types: (a) Toroidal winding of miniature coils on Ferroxcube cores down to 2 mm. diameter; (b) Wiring and assembly of chassis of industrial electronic equipments; (c) Manufacture of electronic test equipment to customer's requirements. Prototype, pre-production and production capacity available. Development and test facilities if required. Write Box W 1456.

GLASS FOR ELECTRONIC USE. Old-established glass manufacturers would welcome inquiries for quantity production of special Glasses, blown or pressed. Willing to carry out development work. Stevens and Williams Lighting Glass Works, Tipton, Staffs. W 1448

TRANSLATION of French, German and Spanish technical papers, articles, etc., especially electronics and microwaves by B.Sc. (Eng.) Hons. Associate of Institute of Linguists. Box W 1447.

WEBB S SERVICE DEPT. for complete renovation of complex communication receivers of any make. Test report issued showing sensitivity selectivity, signal/noise equal to, or better than maker's original figures. Webb's Radio, 14 Soho Street, London, W.1. W 196

FOR SALE

ALWAYS USE Portaway Earth-Continuity and Bonding System for Electrical Safety; simple to install, easy to inspect, etc. Inquiries invited to Portaway, 2 North Park Road, Harrogate. 'Phone 3853. W 312

EXTRUSIONS BY MARLEY Buyers requiring rigid and flexible tubes and sections in thermoplastic materials should ask for a quotation from Marley Extrusions Ltd., Dept. 127 Lenham Maidstone, Kent. Harrietsham 381. W 224

GOVERNMENT SURPLUS ILLUSTRATED Catalogue No. 12, containing over 400 items of electrical, mechanical and Radio equipment for experiments, etc. Price 1s. 6d., post free: Arthur Sallis, 93 North Road, Brighton, Sussex. W 307

HIGH VOLTAGE UNIT by B.T.H. 30 k.v. at 1.0 milliamp. As new, hardly used. Full details, any test on request. £75. O. C. Langford (Birmingham) Ltd., 308 Alcester Road, Moseley, Birmingham, 13. W 1441

LEYLAND ALTERNATOR Set by Auto-Diesels Ltd. Complete self-contained Skid Mounted Power and Lighting set. Engine run 5 hours on test since new. Complete with control panel and 55-gallon fuel tank, ready for immediate service. Engine. Leyland 6-cyl. solid injection Diesel, running at 1,500 r.p.m. 7.4 litre. Alternator. 1,500 r.p.m. direct driven 3 p.h. Alternator incorporating A.V.R. to +2 per cent −2 per cent with an output of 57. 5K.V.A. 83 Amps. Howard Ford & Company Limited, Woolton, Liverpool. Telephone: Gateacre 1386. W 1446

MAGSLIPS, SELSYNS and many other items connected with automatic and remote control mechanisms are marketed by Servo & Electronic Sales Ltd. Brochure available on request. See our display advertisement on page 109. W 202

METAL-GLASS SEALS. Single way hermetically sealed terminals for soldered connexions and fixing. Mostly 1kv and 2kv sizes. New: 65s. per 1,000 assorted. P. B. Crawshay, 94 Pixmore Way, Letchworth, Herts. Tel. 1851. W 215

METALWORK. All types cabinets, chassis racks, etc., to your own specifications. Phil'pott's Metal Works Ltd. (G4BI), Chapman Street, Loughborough. W 3592

100 ALL STEEL 20-Drawer Units, drawer size 5" wide × 3" high × 11¼" long. £6 15s. each. Sample delivered free. N. C. Brown Ltd., Eagle Steel Works, Heywood, Lancs. W 310

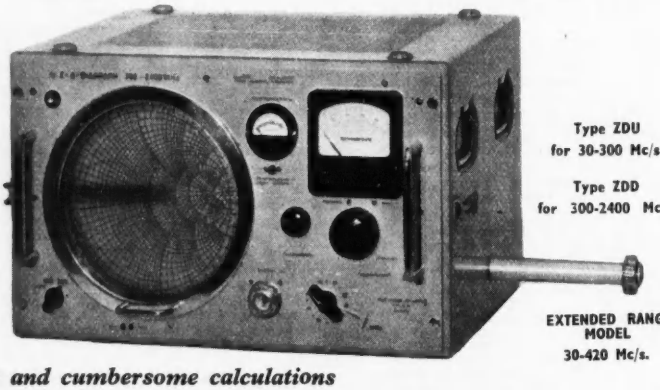
PATENTS

THE TRADE MARKS set out below were assigned on 4th May, 1955 by Electrical Products Export International Limited of 105-109 Judd Street, London, W.C.1, to Thorn Electrical Industries Limited of the same address, without the goodwill of the business in which they were then in use—No. 735340 Mark: Toran. Goods: Electronic apparatus included in Class 9, radio apparatus and television apparatus, and parts included in Class 9 of all aforesaid goods. No. 735341 Mark: Toran. Goods: Apparatus and appliances all included in Class 11 and being electrically operated. W 3729

Z-g DIAGRAPH

A NEW INSTRUMENT FOR plotting impedance

IN RADIO FREQUENCY CIRCUITS



Type ZDU for 30-300 Mc/s.

Type ZDD for 300-2400 Mc/s.

EXTENDED RANGE MODEL 30-420 Mc/s.

Eliminates lengthy and cumbersome calculations

All measurements read direct from interchangeable charts

A UNIQUE DEVICE specially developed for rapid, accurate impedance and admittance measurements by Germany's leading instrument-maker, the Z-g Diagraph indicates results by the light spot projected on to a Smith or similar chart. An entire broadband characteristic is presented visually in a few minutes.

There is direct indication of the transmission characteristic of a four-terminal network or the phase angle between two voltages of unequal amplitude at the same frequency.

Charts available for measurement of Reflection Coefficient, Resistance, Reactance or Magnitude and Phase Angle of an unknown impedance. Usable without recalibration or reconnection.

Write for details of this and other new instruments.

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Special **ELECTRONIC APPARATUS** *for Industry and Government Departments*

This specially adapted 12-channel electro-encephalograph was supplied by Ediswan for electro-medical recording in conjunction with the "man-carrying" centrifuge at the R.A.F. Institute of Aviation Medicine.

Special equipment such as this is regularly being developed and produced by Ediswan for Industry and Government Departments.

Ediswan Engineers have wide experience and they are backed by first-class drawing offices and factories accustomed to working to the appropriate Government specifications.

Enquiries for this type of equipment will receive careful attention.

EDISWAN

RADIO DIVISION

THE EDISON SWAN ELECTRIC COMPANY LTD., 155 Charing Cross Road, London, W.C.2

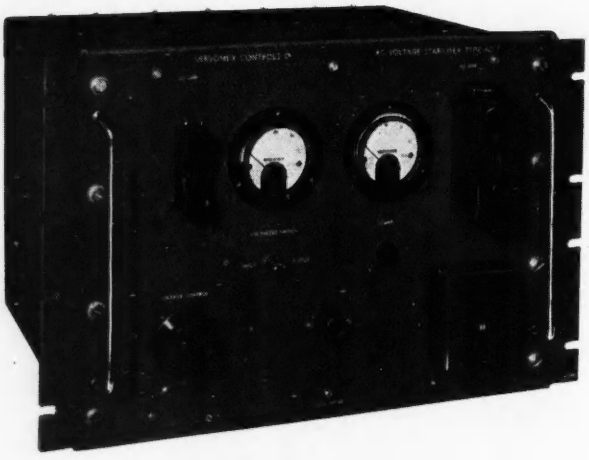
Telephone: Gerrard 8660 *Member of the A.E.I. Group of Companies* *Telegrams: Ediswan, Westcent, London*

EM 132

Even better performance

SERVOMEX

All three instruments use a continuous servo with velocity feedback and provide high power, effectively zero distortion, and a wide range of correction. They will all withstand violent bumping and vibration up to 40g.



A.C.7. U.K. price £143.0.0

- 0 to 30 amps
- Range minus 20% to plus 10%
- 12 volts per second

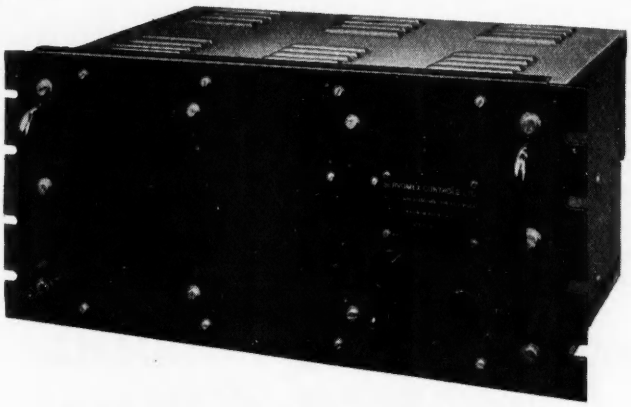
Technical data sheets are available on request.

SERVOMEX CONTROLS LIMITED · CROWBOROUGH HILL ·

ce but no increase in prices!

A.C. VOLTAGE STABILISERS

The two new A.C.2. Stabilisers illustrated are identical except in panel layout. They have several improvements, particularly in mechanical strength, and we take pride in the fact that the price has remained stable since 1952, in spite of large increases in costs.



A.C.2. Mark 2A U.K. price £88.0.0

A.C.2. Mark 2B U.K. price £99.0.0

● 0 to 9 amps ● Range minus 17.5% to plus 8.75% ● 15 volts per second

JARVIS BROOK · SUSSEX · TELEPHONE CROWBOROUGH 1247

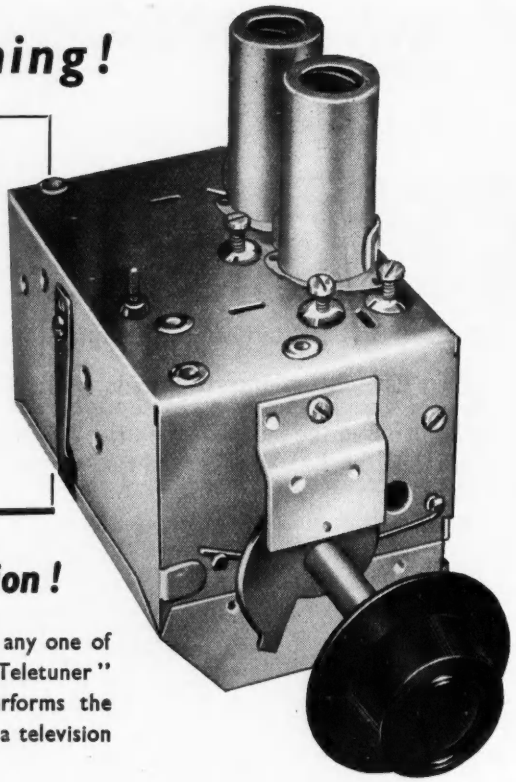
Multi-channel tuning!

Cyldon

"TELETUNER"

(TRADE MARK)

Type TV.12

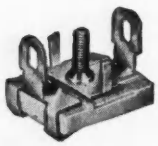


Instant, single-knob selection!

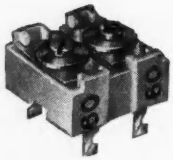
Select a frequency in the 50-220 Mc/s range—select any one of twelve in fact—and this new Cyldon Multi-channel "Teletuner" will handle it. This compact two valve unit performs the functions of R.F. amplifier and frequency changer in a television receiver ***Write for Folder TV 1953.***

FOUR POPULAR 'CYLDON' TRIMMERS

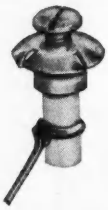
No. 26. Mica Compression Trimmer.



No. 25. Mica Compression Trimmer.



No. 19. Mica Compression Trimmer.



No. 30. Ceramic Trimmer.

**** Full details and specifications available on application***

SYDNEY. S. BIRD & SONS, LTD.

Contractors to Ministry of Supply, Post Office, and other H.M. Government Depts.

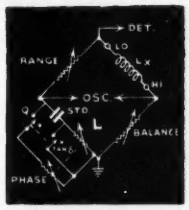
POOLE · DORSET

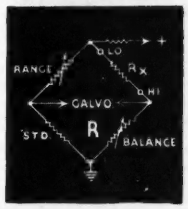
**** Please note address for enquiries and sales correspondence :-***

LONDON SALES & TECHNICAL LIAISON OFFICE,
3 PALACE MANSIONS, PALACE GARDENS, ENFIELD, MIDDX.

Telephone : Enfield 2071-2. *Telegrams : "Capacity, Enfield."*

ACCURATELY MEASURED { **L** - AT 1 OR 10 kc/s; **C** - AT 1 OR 10 kc/s; **R** - AT D.C.





INDUCTANCE, CAPACITANCE, RESISTANCE and power factor measured quickly and accurately on this self-contained and robust instrument. Its industrial-designed appearance fits well in modern surroundings and partners its outstanding electrical performance.

UNIVERSAL BRIDGE TYPE TF 868/1

Inductance from 1 μH to 100H, Capacitance from 1 $\mu\mu$F to 100 μF, and Resistance from 0.1 Ω to 10MΩ.

Single direct reading L.C.R. dial — no multiplying factors involved.

Continuously variable a.c. bridge voltage and automatic detector sensitivity control.

MARCONI INSTRUMENTS

SIGNAL GENERATORS · VALVE VOLTMETERS · Q METERS · FREQUENCY STANDARDS
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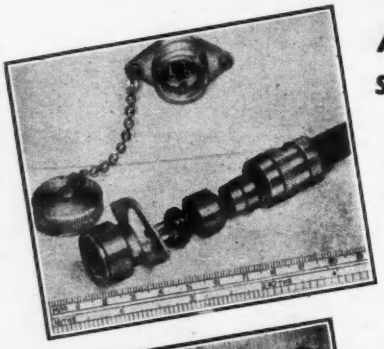
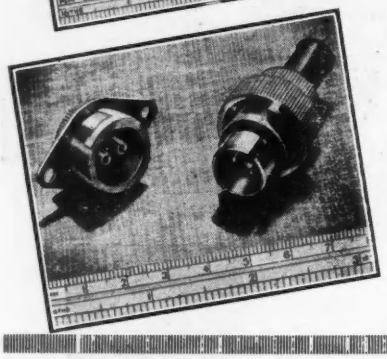
Midland Office: 19 The Parade, Leamington Spa Northern Office: 30 Albion Street, Kingston-upon-Hull

Export Office: Marconi House, Strand, W.C.2.

TC 39R

"Screenectors"





A range of lightweight plugs & sockets for instrumentation, etc.

These non-reversible, screened connectors accommodate cables up to 0.24 in. overall diameter and are available for 1 to 3 ways. Points to note: a spring-loaded locking ring is now incorporated giving vibration-proof locking; resilient skirt maintains screen contact even if locking ring is left undone; contacts assembled on moisture-resistant, nylon-filled, phenolic moulded insulant; rubber cable support to minimise wear at clamping point; housing designed so that the moulded inserts can be interposed, i.e. fixed or free plug, etc.; flange permits use on panels of any thickness.

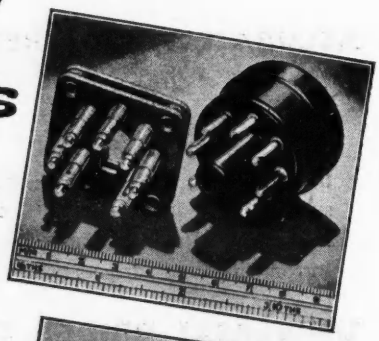
New type plugs (L.788, L.789 or L.790 range) will mate with old type sockets (L.722, L.625 or L.715 range) locking as formerly, and old type plugs will mate with new type sockets but will not lock in as the ring is not spring-loaded. Apart from this, both ranges are interchangeable mechanically and electrically.

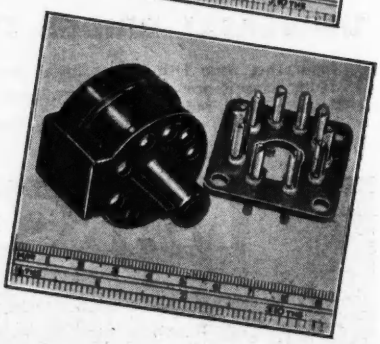
Contact Resistance: less than 2 milliohms per pole.

Working Voltage: 150v d.c. or a.c. peak.

Insulation Resistance: 60,000 megohms at 500v d.c. between contacts and from contacts to housing.

Multi-pole "O-Z" Plugs & Sockets





This range of plugs and sockets conforms to Specification R.I.C.321, and is particularly suitable for rack built equipment and for connecting power pack to chassis, amplifier to receiver, etc. They are available in 5, 7 and 10-pole types, with free plug and fixed socket or fixed plug and free socket. Exceptionally robust in design, their application in the electrical and the electronic industries is very wide, and occasionally they will be found well worth using even if some contacts are left idle. All pins are of the patented "O-Z" design giving low contact resistance. To ensure correct contact a locating key is provided, and until this is correctly positioned, no single pin can make contact. The matching fit of these connectors is exceptional, all poles making positive contact every time. Coupling is so simple that it can be carried out with the eyes shut.

Free parts are moulded from black phenolic material; single screw assembly; right-angled entry.

The socket panel is punched from synthetic resin bonded paper with common fixing holes.

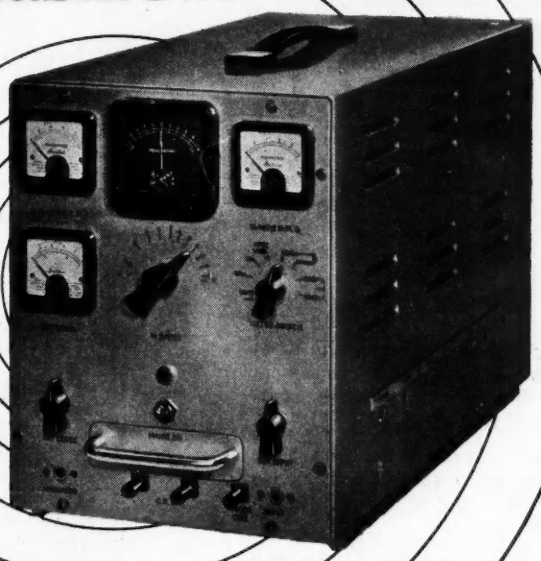
"O—Z" Pins only: U.K. Pat. 567302, 567303. French Patent: 913470, 913471

BELLING & LEE LTD

GREAT CAMBRIDGE ROAD, ENFIELD, MIDDX., ENGLAND

Telephone: Enfield 3322 · Telegrams: Radiobel, Enfield

Made to measure...



The Gaumont-Kalee Flutter Meter is an instrument designed to measure small deviations from constant speed occurring in sound recording and/or reproducing machines. Consisting of a narrow band amplifier, a limiter, a discriminator and detector, and a metering system, the whole unit is self-contained with its own power supplies.

The instrument responds down to zero frequency and will therefore indicate accurately the lowest wow components present. The power consumption is 100 watts and the main characteristics of the instrument may be summarised as follows:—

Operating carrier frequency • 3,000 c.p.s. ± 5%
Minimum input signal • 100 mV
Input impedance • 0.5 megohm
Input amplifier band width • —2db at 2,600 & 3,400 c.p.s.
Effective limiter range • 5 : 1
Peak wow meter F.S.D. • ± 1% peak (centre zero)
R.M.S. Meters F.S.D. • 1.0% R.M.S.
R.S.M. Meters F.S.D. on divide by 5 range • 0.2% R.M.S.
Cross over frequency • 20 c.p.s. ± 5%
Flutter meter response • —3db at 20 c.p.s. —2db at 200 c.p.s. —8db at 300 c.p.s.
Wow meter response • —3db at cross over —1db at ¼ cycle
C.R.O. Output frequency response • Level down to zero frequency —2db at 200 c.p.s.
Analyser output frequency response • —2db at 400 cycles • —1db at ¼ cycle
C.R.O. Output Maximum signal • 140 volts Peak to Peak
Analyser Output for 1% peak to peak deviation • 3.0 volts R.M.S.
Analyser output must be closed upon 0.5 megohms
All meter presentations, accuracy ± 5% F.S.D.

Famous users of the *flutter* meter

B.B.C. Television & Research
E.M.I. Research Laboratories
R.C.A. Photophone Ltd.
Garrard Engineering & Manufacturing Co. Ltd.
Truvox Ltd.
Ministry of Supply
N.V. Philips' Gloeilampen-fabrieken, Holland and Denmark
Post Office Research Department
Compagnia Commerciale di Cinematografia, Milan
Commission Supérieure Technique, Paris
N.Z. Broadcasting Service
Commonwealth of Australia, Melbourne
Wright & Weaire Ltd.
Collaro
Mullard
Egyptian State Broadcasting and in U.S.A., India, Poland, Hong Kong

GAUMONT-KALEE *flutter* METER TYPE 564

Conforms to B.S.1988 : 1953

GB-KALEE

Full details of this equipment may be obtained from :—

G.B-KALEE LTD. Studio Dept. EE/12/55, Mortimer House, 37-41 Mortimer St., London, W.1. Tel: MUSeum 5432

A Member of the BRITISH OPTICAL & PRECISION ENGINEERS' GROUP BOPE

20 Mc/s FREQUENCY MONITOR

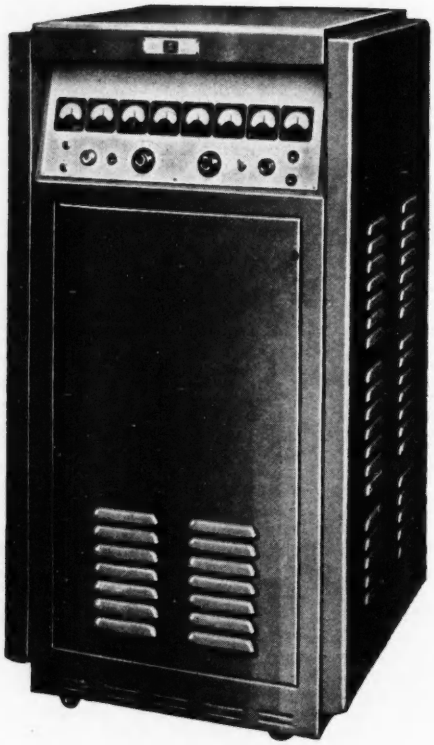
The Automatic Frequency Monitor (20 Mc/s) is but one of a series of high grade monitors now in course of manufacture for the accurate measurement of frequency.

Employing hard valve techniques throughout, it will measure any frequency in the range 10 c/s to 20 Mc/s to an accuracy within ± 1 part in 10^6.

The result, in decimal notation, is presented on eight panel mounted meters each scaled from 0 to 9 and the unknown frequency is automatically remeasured every few seconds.

This new equipment presents a considerable advance in frequency measuring techniques and apart from normal laboratory applications, is ideally suited for incorporation in production testing routines.

Full technical information on this and other frequency measuring equipment is available on request.



CINEMA TELEVISION LTD

A COMPANY WITHIN THE RANK ORGANISATION LIMITED

WORSLEY BRIDGE ROAD · LONDON · S.E.26

HITHER GREEN 4600

SALES AND SERVICING AGENTS:

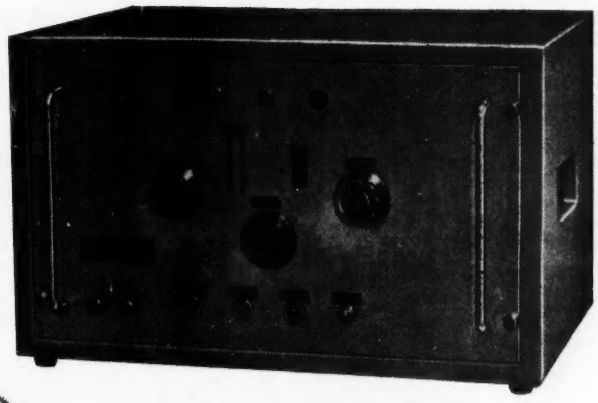
Hawnt & Co. Ltd., 59 Moor St. Birmingham, 4

Atkins, Robertson & Whiteford Ltd., 100 Torrisdale Street. Glasgow, S. 2

F. C. Robinson & Partners Ltd., 122 Seymour Grove, Old Trafford, Manchester, 16

RIVLIN

Sweep Frequency Oscillator



MOTOR OR MANUAL DRIVE AT WILL.
FREQUENCY RANGE 20cs. TO 3Kcs

Meets Ministry specifications for valve vibration testing.

Also suitable for general vibration work.

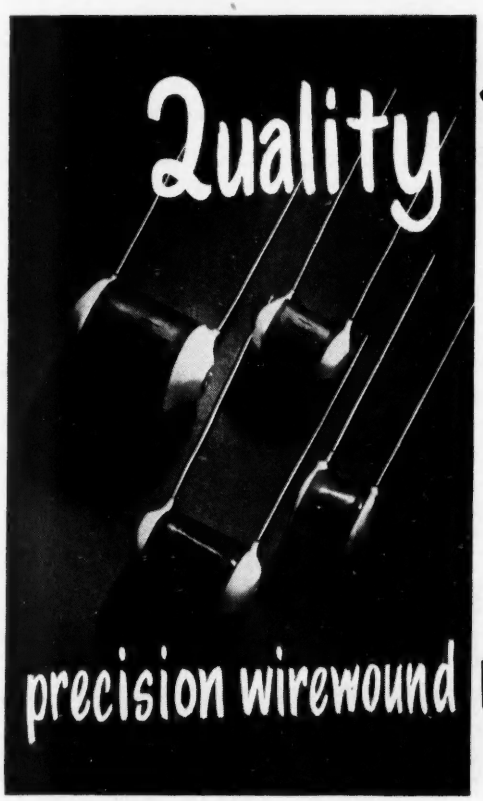
Automatic reverse and stop or cycle over complete range or any selected band.

Constant output 0.1V into 600 ohms or as specified.

Sweep rate 2 octaves per minute (can be varied to suit customers requirements).

Full information from

RIVLIN INSTRUMENTS LTD.
7a Maitland Park Villas London N.W.3 *Gulliver 2960*



Quality PLUS delivery

THE range of Rivlin Precision Wirewound Resistors has been extended to include miniature types. As with existing Rivlin Resistors they are fully heat treated and a heavy polythene coating renders them completely impervious to the effects of humidity and temperature.

★ Rivlin Resistances can be adjusted to 0.1% of the required value, or 0.01Ω whichever is the greater.

★ Any value in the range 0.1Ω to 75,000Ω can be supplied with a temperature co-efficient of 0.002% per degree centigrade, and up to 1MΩ with a temperature co-efficient of 0.02% per degree centigrade. Standard rating—1 watt.

★ Rivlin Wire Wound Resistances fully comply with Services specifications.

★ *American types reproduced.*

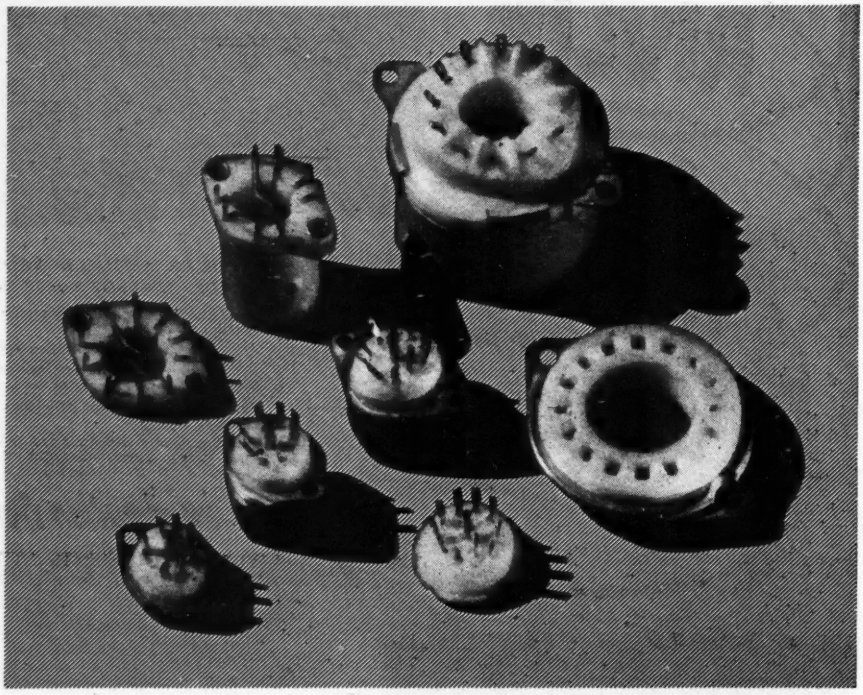
14 to 21 days delivery

precision wirewound resistors by RIVLIN

RIVLIN INSTRUMENTS LTD.
7a Maitland Park Villas, London, N.W.3. *Gulliver 2960*

'FLUON'*

a new insulant for electronics



These valve holders, made from 'FLUON' polytetrafluoroethylene by The Edison Swan Electric Co. Ltd., demonstrate the remarkable insulating properties of 'FLUON':

Operating temperature range	– 80°C. to 250°C.
Operating frequencies	60 to 10^9 C.P.S.
Power Factor	0.0001
Dielectric Constant	2.0
Water Absorption	NIL
Non-tracking	

Can 'FLUON' solve YOUR problems?

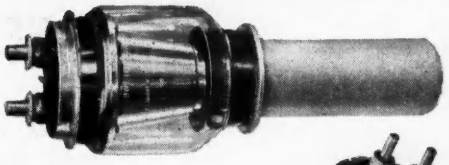
* *'FLUON' is the registered trade mark for the polytetrafluoroethylene manufactured by I.C.I.*

Please ask for full technical data.

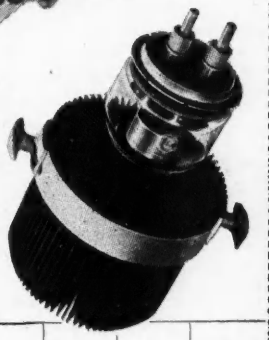
IMPERIAL CHEMICAL INDUSTRIES LTD., LONDON, S.W.1.

P.566

Valves for R.F. Heating



POWER OSCILLATORS

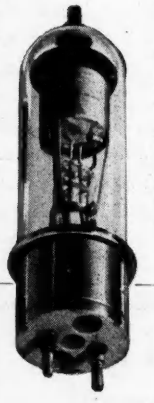


The increasing use in industry of R.F. heating has shown the need for units to provide outputs between 10 and 50 kW. These two products of the English Electric Valve Company are designed for R.F. generators of 6kW and upwards, and have been deve'oped expressly for operation under the arduous conditions imposed by factory use. Both types are available in air-cooled and water-cooled versions.

Type	Maximum operating Frequency (Mc/s)	Cathode	Dimensions (maximum)		Filament		Maximum Anode Voltage	Maximum Anode Dissipation (kilowatts)	Useable Emission (Amperes)	Amplification Factor	Mutual Conductance (mA/V)
			Length mm.	Diameter mm.	Volts	Amperes					
BR.1102	50	Th.	483	241	8·2	230	12·0	20·0	45	42	20·0
BW.1102	50	Th.	473	152	8·2	230	12·0	20·0	45	42	20·0
BR.1103	100	Th.	356	203	6·0	120	8·5	10·0	16	25	9·5
BW.1103	100	Th.	343	116	6·0	120	8·5	10·0	16	25	9·5

Th. denotes Thoriated Tungsten. BR. denotes Air-cooled. BW. denotes Water-cooled.

POWER RECTIFIERS



English Electric Valve Company produce these two power rectifiers, which are particularly suitable for use in connection with the power oscillators described above. The range also includes mercury vapour filled and xenon filled rectifying valves with outputs from 7kW to 630kW. Full data and operating instructions for these and for power oscillators are available on request.

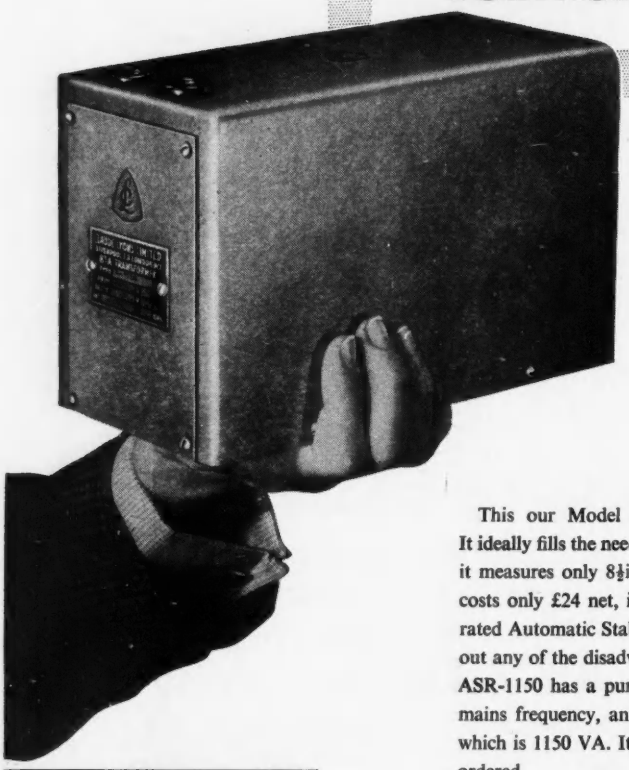
Tube Type	C.V. Number	Filling	Output in Kilowatts
AH.211	CV.532	Mercury vapour	90
AH.221	CV.5	Mercury vapour	36

'ENGLISH ELECTRIC'

ENGLISH ELECTRIC VALVE CO. LTD. *Waterhouse Lane, Chelmsford*
Telephone: Chelmsford 3491

AP 300/27

A NEW-PRINCIPLE A-C AUTOMATIC VOLTAGE STABILISER



This our Model ASR-1150 Automatic Voltage Step Regulator. It ideally fills the need for a cheap, small and light Stabiliser. Although it measures only 8½in. x 4½in. x 5in., weighs as little as 11 lbs., and costs only £24 net, it has a performance fully equal to any similarly rated Automatic Stabiliser of the resonated, saturated core type, without any of the disadvantages.

ASR-1150 has a pure output waveform, is unaffected by changes in mains frequency, and works equally well from no-load to full load, which is 1150 VA. It has a stabilised output at 230V unless otherwise ordered.

Many other Automatic Voltage Stabilisers are now manufactured by us, and all are available for immediate delivery. In some cases the constancy of output is as high as 0.15%. Models are available from 200 VA to 30 kVA, single phase. 3-Phase Stabilisers are also available. Prices are *extremely* competitive.

We can supply from stock all types of American tubes, condensers, valves, potentiometers, etc.

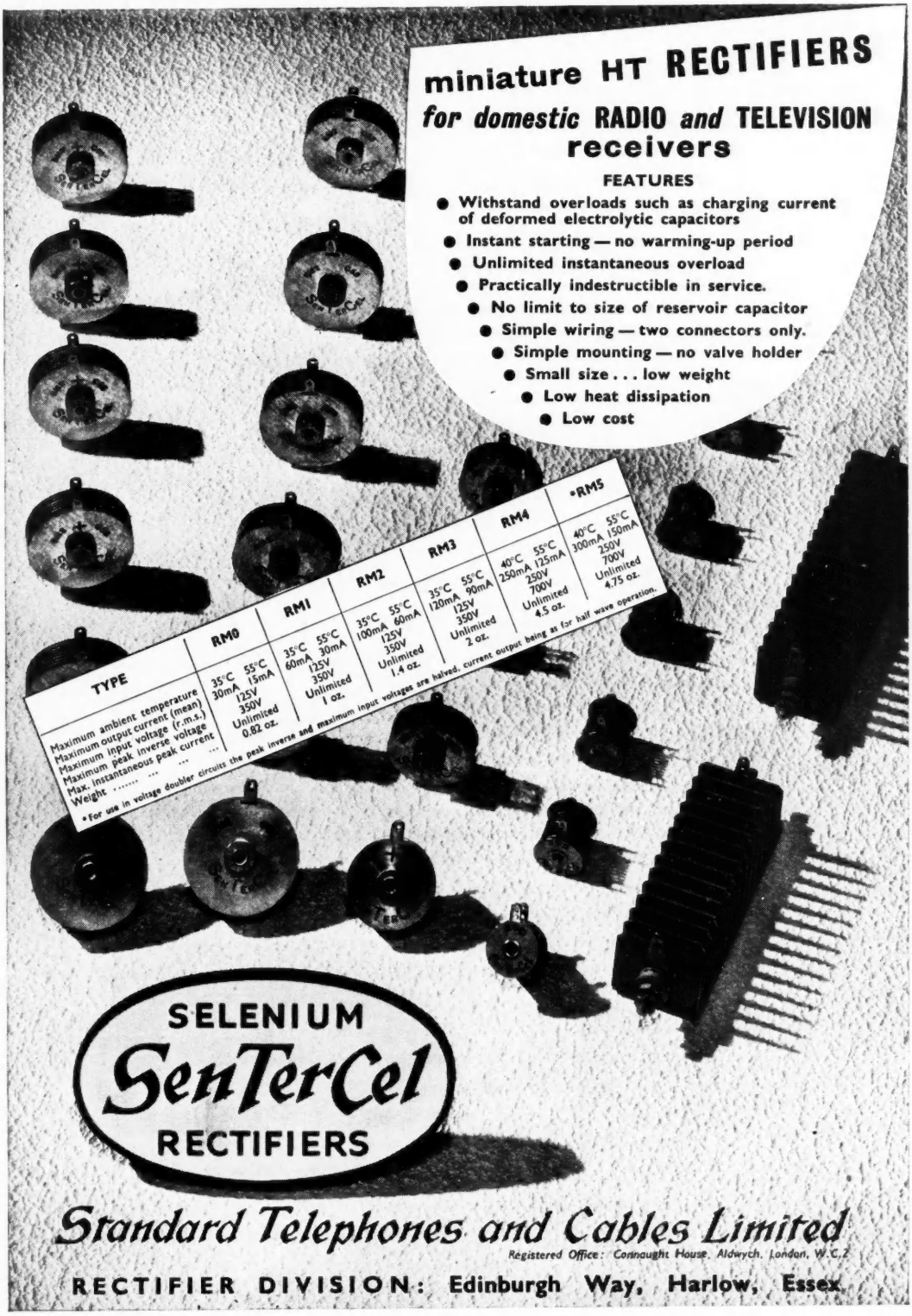
★ *MEMO : If you are interested in infinitely-variable Transformers, do not forget the almost indispensable "VARIAC" (Reg'd. Trademark). Models are available from 170VA to 21kVA. Our Catalogue V-549 (3rd Edition) tells the whole story, and will gladly be mailed free and post free, on request.*

The *NEW "ASR-1150"* costs only £24 net

Complete information is obtainable from

CLAUDE LYONS LTD.,
Electrical and Radio Laboratory Apparatus, etc.

Head Office and Works: 76, OLDHALL STREET, LIVERPOOL 3, LANCS.
Southern Factory: VALLEY WORKS, WARE ROAD, HODDESDON, HERTS.
(A.10 main London/Cambridge Road, at Junction of A.602)


miniature HT RECTIFIERS
for domestic RADIO and TELEVISION receivers
FEATURES
● Withstand overloads such as charging current of deformed electrolytic capacitors
● Instant starting — no warming-up period
● Unlimited instantaneous overload
● Practically indestructible in service.
● No limit to size of reservoir capacitor
● Simple wiring — two connectors only.
● Simple mounting — no valve holder
● Small size . . . low weight
● Low heat dissipation
● Low cost
TYPE | RM0 | RM1 | RM2 | RM3 | RM4 | *RM5
Maximum ambient temperature | 35°C 55°C | 35°C 55°C | 35°C 55°C | 35°C 55°C | 40°C 55°C | 40°C 55°C
Maximum output current (mean) | 30mA 15mA | 60mA 30mA | 100mA 60mA | 120mA 90mA | 250mA 125mA | 300mA 150mA
Maximum input voltage (r.m.s.) | 125V | 125V | 125V | 125V | 250V | 250V
Maximum peak inverse voltage | 350V | 350V | 350V | 350V | 700V | 700V
Max. instantaneous peak current | Unlimited | Unlimited | Unlimited | Unlimited | Unlimited | Unlimited
Weight .... | 0.62 oz. | 1 oz. | 1.4 oz. | 2 oz. | 4.5 oz. | 4.75 oz.
*For use in voltage doubler circuits the peak inverse and maximum input voltages are halved, current output being as for half wave operation.
SELENIUM
SenTerCel
RECTIFIERS
Standard Telephones and Cables Limited
Registered Office: Connaught House, Aldwych, London, W.C.2
RECTIFIER DIVISION: Edinburgh Way, Harlow, Essex.

UNDERGROUND MOVEMENT

In the last decade of the nineteenth century the Railway Companies turned their attention to the use of electricity as a means of tractive power.

The long vision of Thomas Taylor who saw the future for porcelain insulation in the development of the electrical industry was concomitant with these new lines of progress. Electricity was on the move, and the combined engineering and ceramic skills of Thomas Taylor and William Tunnicliff enabled them to lead the field in guiding it into safer channels.

Electricity made possible the underground lines of London, and in the first twenty years the considerable far-reaching advances made in electrifying lines all over the world, justified the foresight of Taylor and the visions that had inspired the layout and policy of the firm he had helped to found.

Today with Railway Development again in the news Taylor, Tunnicliff once more are called upon to play their part in its electrified progress.

OVERHEAD LINE INSULATORS
SWITCHGEAR INSULATORS
BUSHES AND BUSHINGS
DIE MADE ARTICLES FOR LOW VOLTAGE APPLICATIONS
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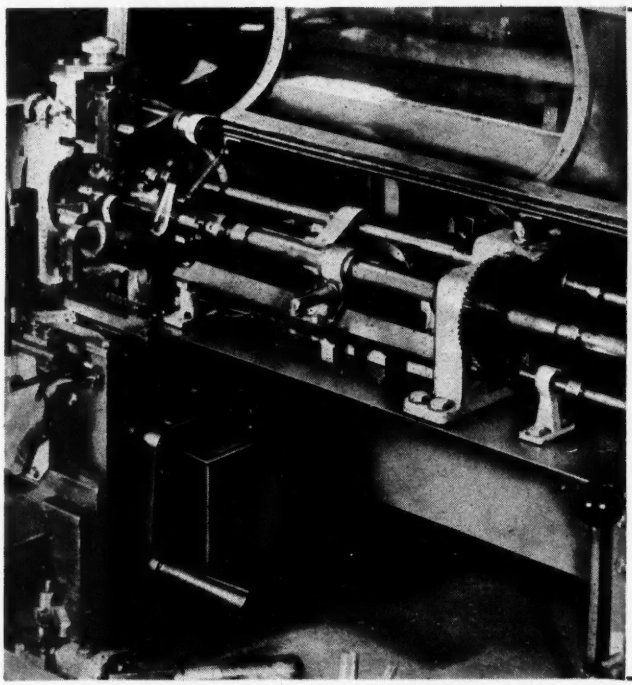
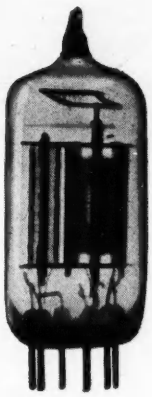
MODERN MINIATURE VALVE PRODUCTION...an Osram *series*



Grid winding machine



X-ray photograph of modern miniature valve, Osram LN 309.

Precision tooling

In high-grade miniature valve production, tooling is an art in itself. Closer clearances, finer gauge wires, even the electrodes themselves all require most careful handling. The assembly of Osram miniature valves is carried out by skilled workers under most favourable conditions. Every detail of production has been studied to make Osram miniatures pass the most exacting tests. This overall care — from raw materials to the finished product — results in these valves being specified by discriminating designers.

Osram
VALVES
characteristically good

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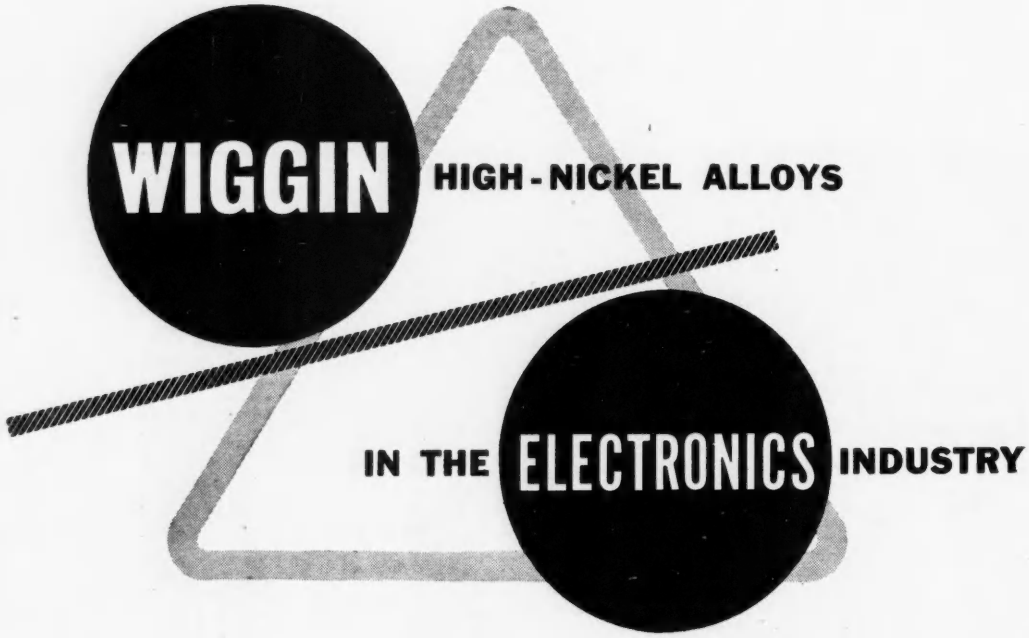

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'GFA' nickel for anodes, plates and other electrodes. 'Gassy' nickel for terminal pins. 'O' nickel for sleeves of indirectly heated cathodes. 'HTC' nickel for resistance thermometers. 'HPA' and 'HPB' high purity nickel for cathodes.

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Nickel-manganese alloys for electrode support wires, grids, etc.

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Resistance materials for all types of electrical resistors, heating elements.

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Nickel-copper alloy for non-magnetic parts of cathode-ray tubes; a low temperature co-efficient of resistance suitable for instrument and control resistances.

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Nickel-iron alloys with controlled expansion properties. For glass/metal seals.

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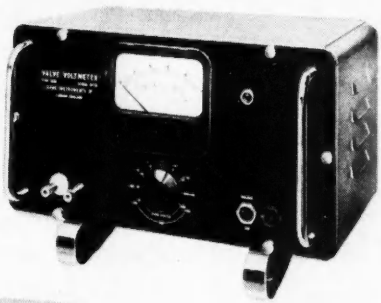
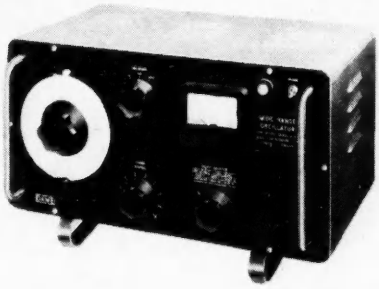


VALVE VOLTMETERS
Types 613 & 614



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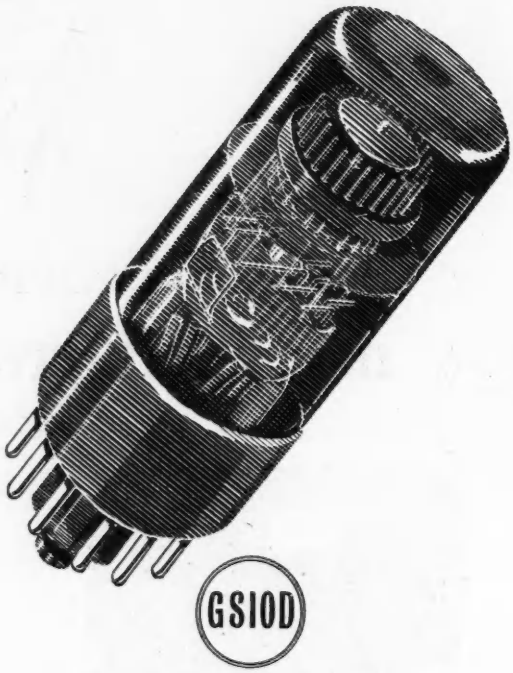
Operating at a current of only 1 milliamp at 475 volts this tube is ideally suited as a storage unit in computors where low power and heat dissipation are major considerations.

A visual indication of the stored data is available by end-viewing as on previous Dekatron types.

Access to all ten cathodes and anode bottom cap on the duodecal base enables the tube to be used as a ten-way switching element.



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Detailed information, including data, curves, and circuits of our wide range of counter and selector tubes, voltage stabilizers, reference and trigger tubes, is contained in the 1954-55 Handbook of Cold-Cathode Tubes. Available on application to:

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ORIGINATORS OF THE DEKATRON

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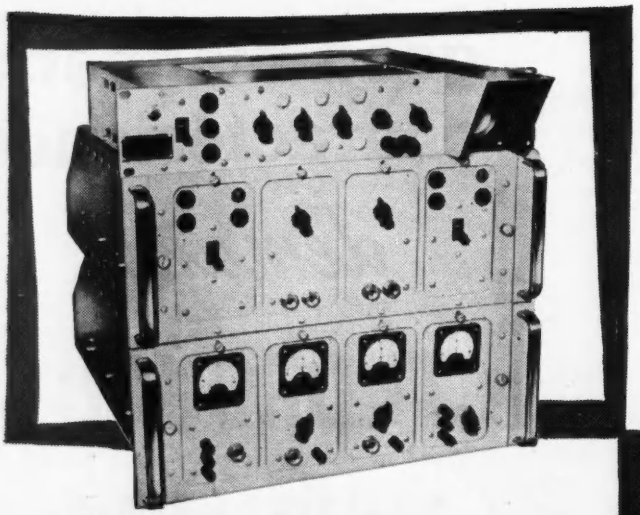

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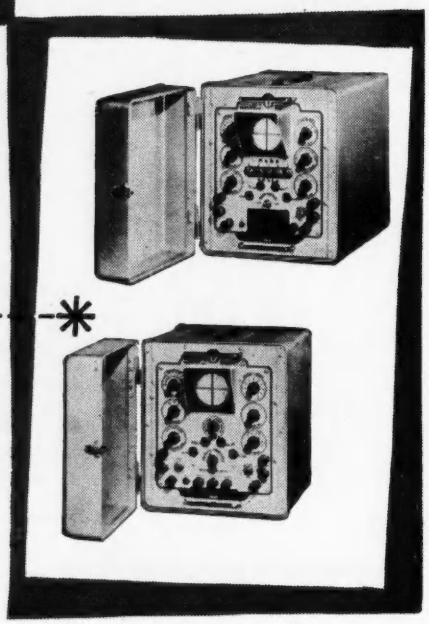
✱ FREQUENCY SHIFT TELEGRAPH TERMINAL EQUIPMENT

Designed to work in conjunction with conventional receivers for the reception in dual diversity, of wide or narrow band frequency-shift and on/off, or reversed on/off, hand or automatic radio telegraph and teleprinter signals. Up to 85 db of rapid variation in input signal level can be accepted with frequency-shift working, and up to 35 db with on/off or reversed on/off, working. Keying speeds up to 200 bauds can normally be handled—this range can be extended if required. This versatile receiver is also suitable for use with the new 50 c/s Pilot Carrier frequency shift system.



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This equipment is available either in portable form or arranged for standard width rack mounting. There are two units each 18¾" x 11¼" x 13¼", both mains driven, either may be used independently for certain tests or both may be used in combination to cover a comprehensive series of tests. These tests, which need not interfere with normal transmission, cover transmission and reception. The transmitting unit can send perfect or distorted signals at any speed from 20 to 80 bauds or up to 200 bauds with modification. It can generate reversals and character repetitions and incorporates a 100 character test message sender. An additional feature of this unit is its use as a relay tester.

The receiver unit indicates the distortion on a *working circuit* without interrupting the service. Each element of a start-stop signal appears separately on the CRT which produces a spiral time base display. Adjustable speeds from 20 - 80 bauds or up to 200 bauds with modification.

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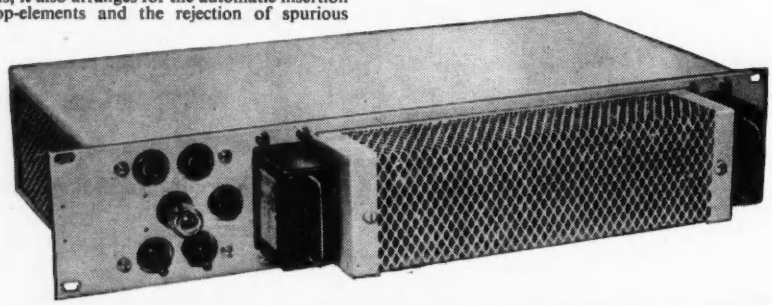
A mains operated, start-stop, five unit code equipment. Designed for use in both radio and line teleprinter circuits to regenerate and correct distorted signals, it also arranges for the automatic insertion of correct length stop-elements and the rejection of spurious signals.

Details of these and other telegraph equipments will gladly be sent on request.



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A NEW TECHNIQUE IN HIGH SPEED WAVEFORM MONITORING

BANDWIDTH :
10 kc/s to 300 mc/s

INPUT IMPEDANCE OF EACH PROBE :
Approx. 1 pf (input element of variable capacity divider)

MAXIMUM SENSITIVITY :
Full Scale Deflection for 1 Volt input

TIME SCALE :
Variable from .05 microsecs to 5 microsecs

RECURRENCE RATE OF MONITORED WAVEFORM :
100 c/s to 10 kc/s

CALIBRATION :
Provision is made for accurate measurement of time and voltage scales of a waveform

PREVENTION OF JITTER :
A circuit is incorporated for providing a stable display when a monitored waveform is jittering with respect to its driving pulse.

HIGH SPEED RECURRENT WAVEFORM MONITOR TYPE 500

The wide bandwidth and high sensitivity of the instrument as well as the very high input impedance result from the use of a sampling technique. During each recurrence a measurement is made of the instantaneous amplitude of one point in the waveform. This measurement is amplified and applied to the cathode ray tube as one co-ordinate of a graph of the waveform. During subsequent recurrences, instantaneous measurements are made of different points, resulting, after about 100 recurrences, in a complete graph.

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ELECTRICAL CO LTD · TRAFFORD PARK · MANCHESTER, 17

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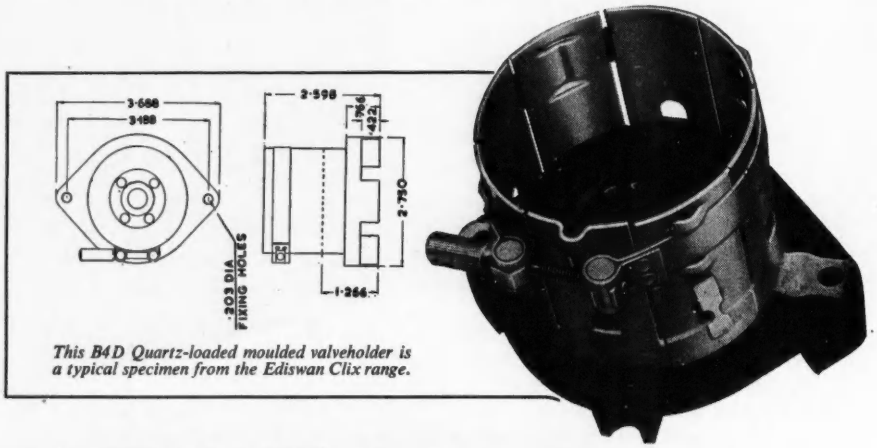
valveholders

for industry

Ediswan Clix Valveholders give continuous trouble-free operation under the most exacting conditions encountered by Industrial Electronic equipment.

The very wide range includes B7G, B8A, B9A, B9G and a number of larger types such as B4A, B4D and B4F all complying with the appropriate specifications for Government equipment. Insulation materials include P.T.F.E., Nylon-phenolic and Quartz-phenolic; contact material is silver-plated Beryllium copper. Catalogue of complete range of Radio, Television and Electronic components available on request.



This B4D Quartz-loaded moulded valveholder is a typical specimen from the Ediswan Clix range.

EDISWAN

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RADIO, TELEVISION & ELECTRONIC COMPONENTS

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Send for Yours To-day . . .

Connollys have produced five handy "slide rule" tables which give, at a glance, considerable data not normally available in ready form, concerning winding wires as follows:

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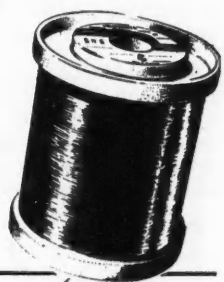
Conymel M	**" " " " "**	
Conymel T	**" " " " "**	
Conymel X	**" " " " "**	

We shall be pleased to mail you one or more sets, if you will kindly write us on your business letterheading.



CONNOLLYS *Winding Wires*

The largest manufacturers of fine enamelled wires in the world

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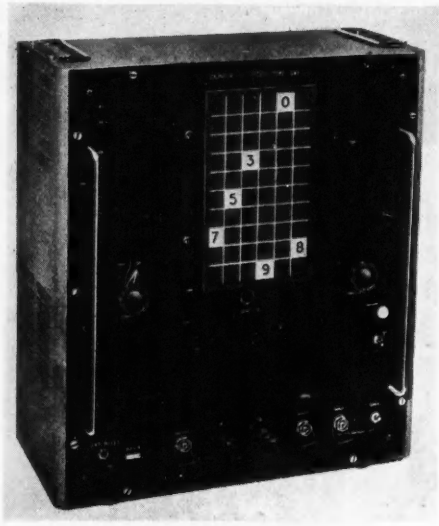
High-Speed ELECTRONIC COUNTER

Type 865



THIS instrument operates on electrical inputs of any waveform between 1.5 and 50V peak amplitude at speeds from zero up to 1 million per second. It records the total count of up to 999,999 on a direct reading decimal display of exceptional brilliance and clarity, whilst a built in four-figure electromechanical counter extends the range to 9,999 million.

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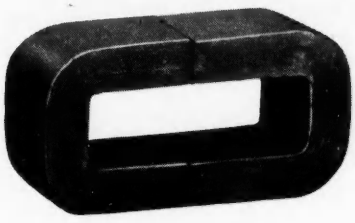
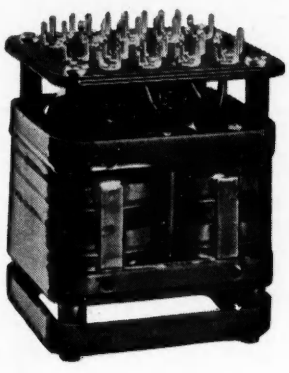
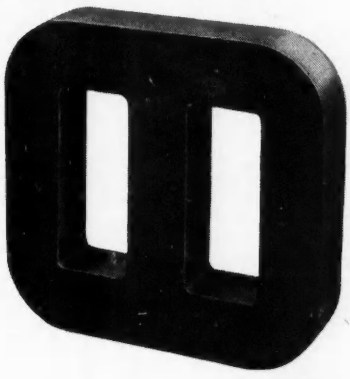
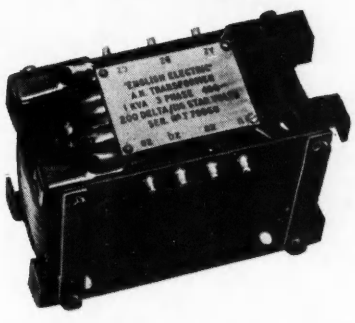
'C' Cores and 'E' Cores
for transformers and chokes









'ENGLISH ELECTRIC' 'C' Cores and their later development, 'E' Cores, are ideal for use in open type transformers and chokes as well as the oil-filled or cast resin types. Their use enables the complete transformer to be up to 30% smaller and lighter. Made in a comprehensive range of sizes, most 'C' Cores are available from stock and normal requirements of 'E' Cores on a short delivery.

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'ENGLISH ELECTRIC'

THE ENGLISH ELECTRIC COMPANY LIMITED, QUEENS HOUSE, KINGSWAY, LONDON, W.C.2

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DUBILIER HIGH STABILITY RESISTORS

are available in ratings up to 2 watts dissipation and in resistance values of 10 Ω to 10M Ω ± 5%; 50 Ω to 5.1M Ω ± 1% and 100 Ω to 1M Ω ± 1%. The temperature coefficient ranges from — 0.02% to — 0.06% per degree Centrigrade and the noise level from less than 0.5 μV/V to not greater than 1.0 μV/V.

DUBILIER PRECISION WIRE WOUND RESISTORS

are wound to normal, intermediate and close limits of ± 1.0%; ± 0.25% and 0.1% respectively. The closest limit for values of less than 2 Ω is ± 0.01 Ω. The resistance range available is from 0.1 Ω to 1.0M Ω. All types are non-inductively wound. Noise-free contact between the resistance wire and connecting leads is ensured by an exclusive moulding process.

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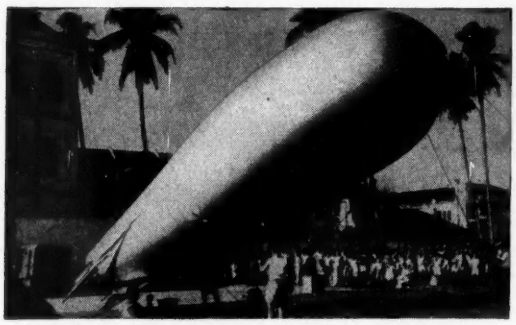


Marconi Surveying Service

LEFT. Balloon operations on the Ipoh-Telok Anson route in Malaya.

RIGHT. The mast is up and the motor generator is running during the survey of the Nigerian multi-channel system.

BELOW. The V.H.F. mobile survey team erect their mast.

Before planning any communication system, and particularly a microwave or V.H.F. multichannel system, a survey of the propagation conditions over the proposed path or area is essential. Similar, but less exhaustive surveys, are also necessary before planning V.H.F. mobile systems. Such surveys are undertaken by Marconi's, one of the very few radio manufacturers who do so. The teams engaged in the work may be called upon to operate in desert, swamp and jungle, over which line and cable routes would be impractical, on windswept moorlands or in densely populated city and suburban areas. Surveys are being, or have already been carried out all over the world, including: Uganda, Kenya, Tanganyika, Nigeria, Gold Coast, Tangier, Azores Norway, Turkey, Greece, Malaya, Ceylon, West Indies, Sweden, and also, of course, in Britain.

Over 80 countries now have Marconi-equipped telegraph and communications services. Many of these are still giving trouble-free service after more than twenty years in operation.

Lifeline of communication

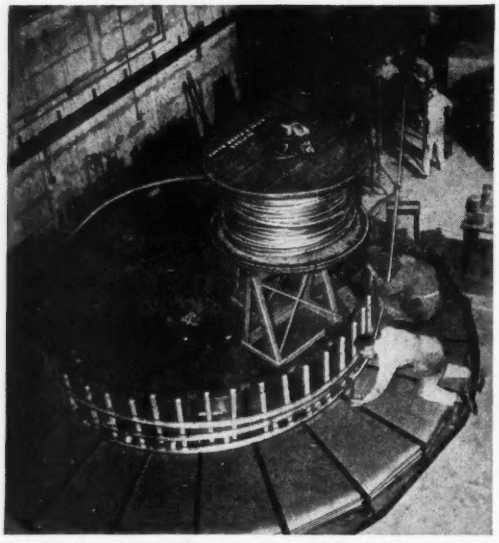
MARCONI

COMPLETE COMMUNICATION SYSTEMS

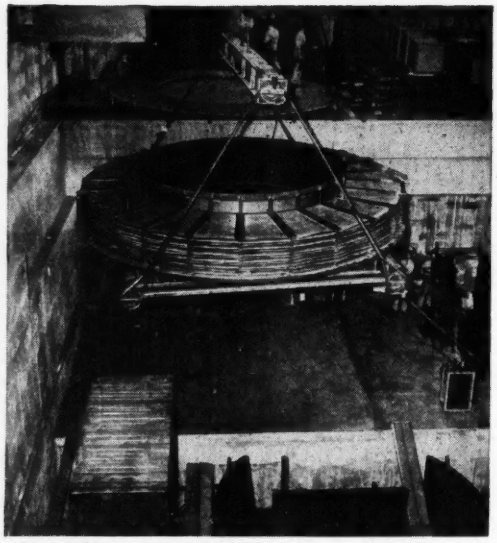
Surveyed, planned, installed, maintained

MARCONI'S WIRELESS TELEGRAPH CO., LTD., CHELMSFORD, ESSEX

LC 10

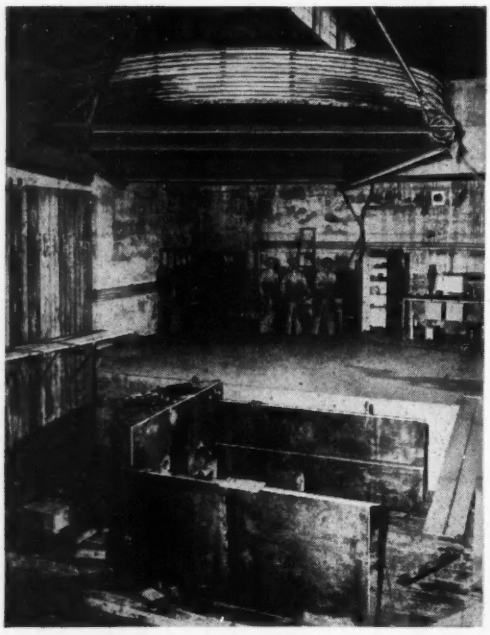


The aluminium being pulled through a tensioning device and wound on to the layer of pancakes that form the magnet energizing coils.



The completed job being lifted from the winding table. The partially built accelerator magnet is shown in the foreground.

CYCLOTRON WINDINGS



Another view of the completed winding.

WITH JAMES BOOTH'S SPECIAL ALUMINIUM SECTION

Following the success at Liverpool University, the Australian National University Research School of Physical Science at Canberra, used a special extruded section of square contour with a central round hole for the windings of the electromagnet of the cyclotron recently constructed in Australia. This meant a demand for 16 continuous lengths of section each 2,300 ft. long, and the successful production of faultless lengths of such extent represents no small metallurgical achievement. If, however, the versatility of aluminium and the flexibility of the extrusion process is used in conjunction with the art and perseverance of our skilled technicians, the most ambitious aspirations of the drawing board can often be brought to reality.

If your problem is unusual—so also will be our endeavours to help you if you care to consult us, without obligation, of course.

Photographs — reproduced by courtesy of the University — show the job in progress.

JAMES BOOTH & COMPANY LTD. BOOTH BIRMINGHAM ARGYLE ST. WORKS, BIRMINGHAM 7

Extrusions, large forgings, plate, sheet, strip, tubes and wire in brass and copper, as well as light alloys.

CYC 1

AUDIO
PERFECTION

Garrard

THE
FINEST
RECORD PLAYING
EQUIPMENT
IN THE
WORLD

CARRARD
SWISS

The Dalic Process of Electrodeposition

Renovating the zinc protective coating of a propeller blade on site at Air France

Characteristics of Dalic Deposits

Deposit	Brinell hardness of deposits	Time to deposit 0.0001 in. (sec.)
Bismuth	50	7.6
Cadmium	40	2.5
Chromium	600	63
Cobalt	250	7.6
Copper	150	2.5
Gold	100	6.2
Indium	<1	2.5
Iron	175	10.2
Lead	20	3.8
Nickel	500	5.1
Platinum	200	17.5
Rhodium	500	70
Silver	60	5.1
Tin	1	2.5
Zinc	70	3.8

The DALIC PROCESS of Electrodeposition provides a wide range of coatings on to most basis materials, including aluminium. It is particularly suitable for plating selected areas without stopping-off, for on-site work, and for plating assemblies or components which may not be immersed in plating solutions.

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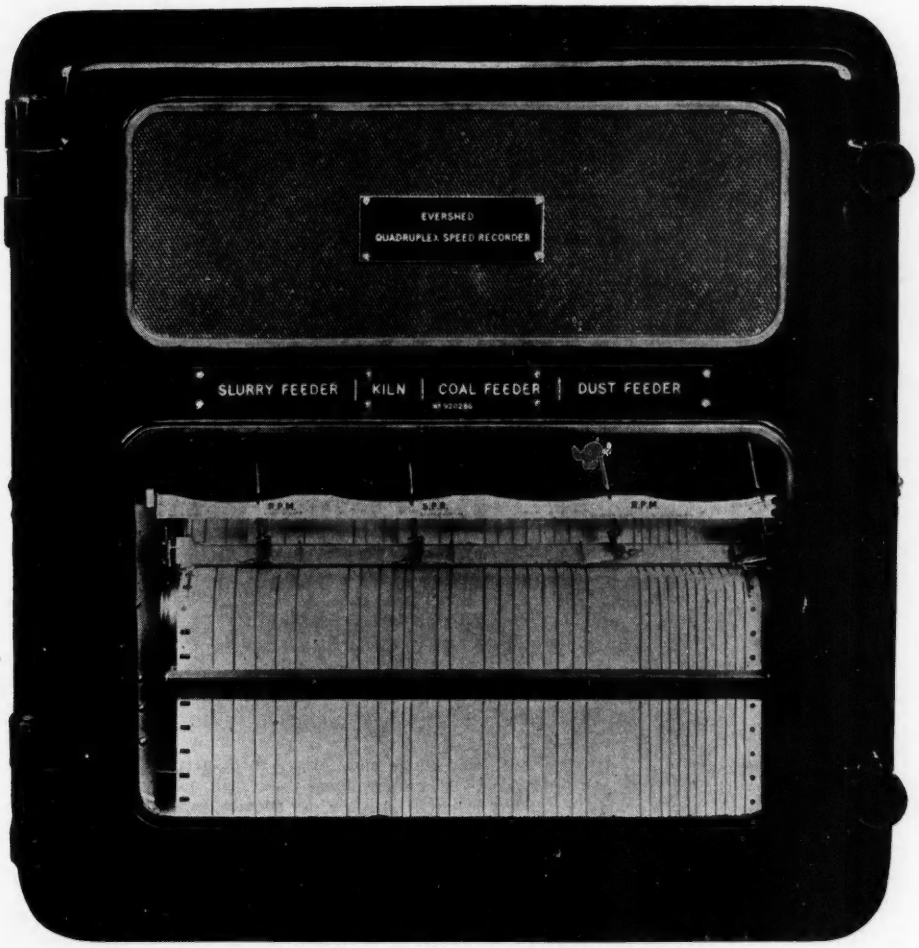

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Evershed Recorders provide a detailed, sensitive and accurate record 24 hours a day, 7 days a week. They measure electrical quantities such as current, pressure, frequency, power or power factors. They measure mechanical quantities such as speed or water level. They plot, automatically, a given operation on a time basis or in combination with a quantity record.

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Evershed Recorders are described in Publication No. EE222, a copy of which will be sent on request.

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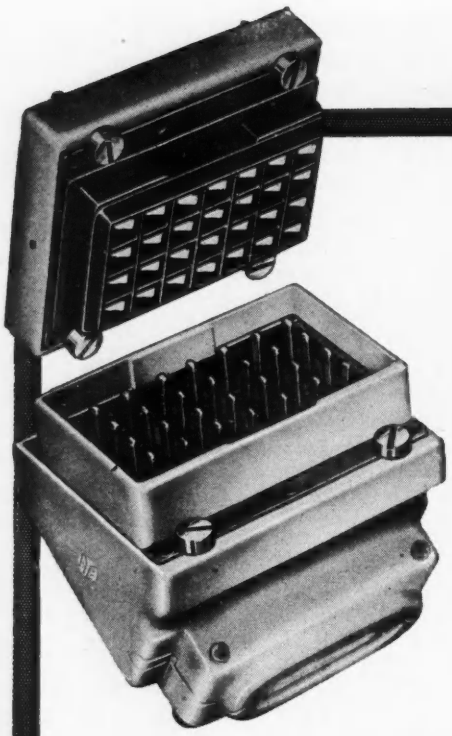

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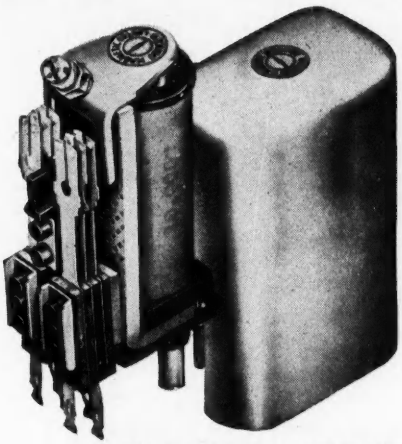
EXNING RD., NEWMARKET PHONE: NEWMARKET 3181

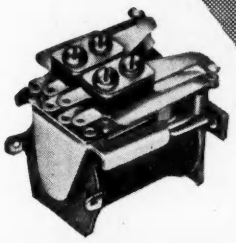
R/H

RELAYS



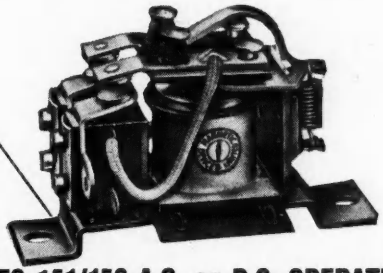
SERIES 2400 D.C. OPERATED

Contacts up to 6 pole, light or heavy duty.
Dimensions: $1\frac{7}{16}$" x $1\frac{5}{8}$" x $2\frac{1}{2}$" above chassis.



SERIES 595 D.C. OPERATED

Contacts up to 6 pole rated at 5 amps.
Dimensions: $1\frac{3}{8}$" x 1" x $1\frac{7}{16}$".

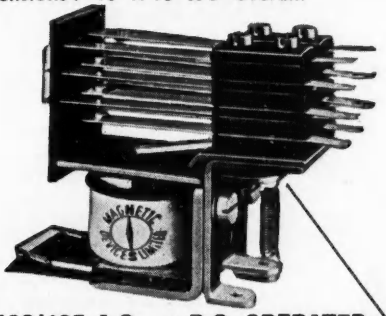


SERIES 151/156 A.C. or D.C. OPERATED

Contacts up to 2 pole rated at 15 amps.
Dimensions: $1\frac{7}{8}$" x $1\frac{7}{8}$" x 3" overall.

SERIES 595H D.C. OPERATED

Contacts up to 2 pole rated at 5 amps. Hermetically sealed on octal type base.
Dimensions: $2\frac{5}{8}$" overall x $1\frac{9}{16}$" dia.



SERIES 100/105 A.C. or D.C. OPERATED

Contacts up to 6 pole rated at 10 amps.
Dimensions: $1\frac{3}{4}$" x $1\frac{1}{8}$" x $2\frac{7}{8}$" overall.

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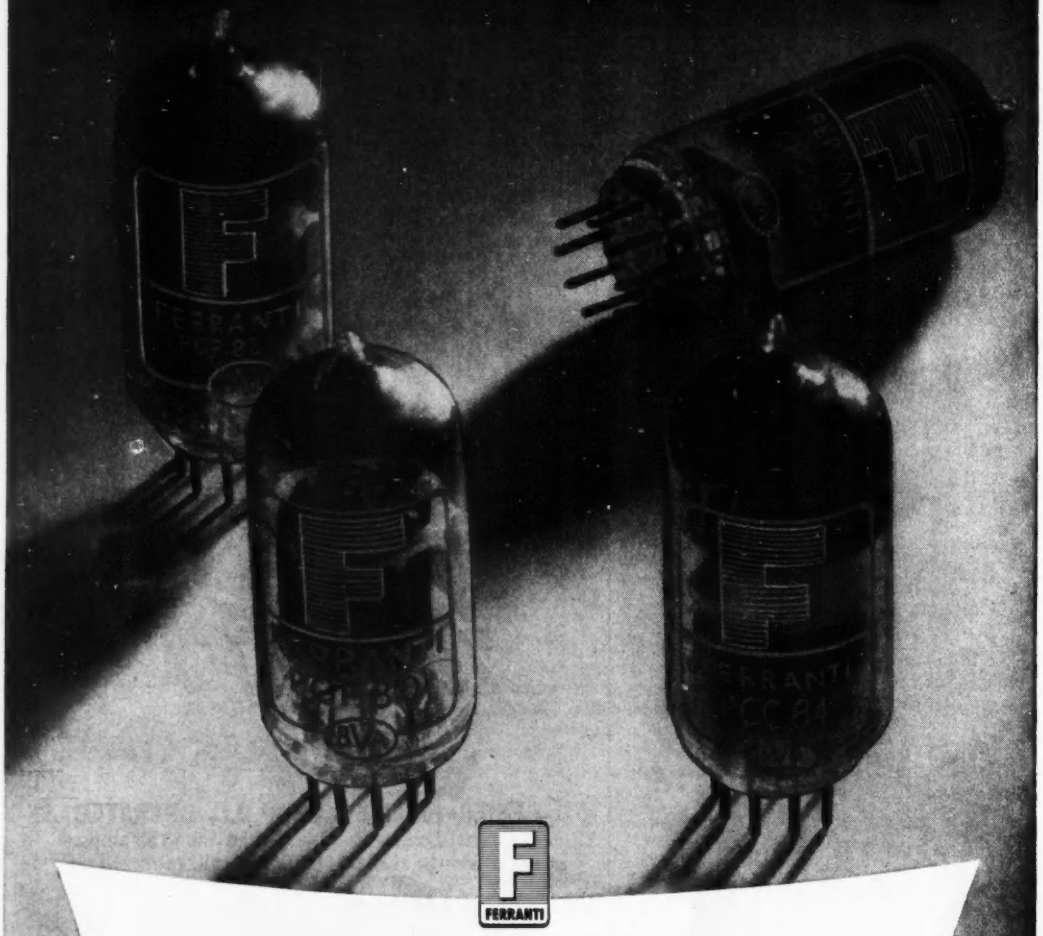
MD9

Ferranti Valves for Band III Television Reception



All glass B9A based valves designed to operate in the 200 Mc/s waveband for band III T.V. Reception. Types available are as follows:

PCC84	Cascode R.F. Triode
PCC85	Double Triode
PCF80	Triode Pentode Frequency Changer
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Hermetically sealed, oil filled, with C-type cores.
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Resin Moulded, with standard laminations.
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CEECOPT:
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LAMCLOS:
Enclosed type, with standard laminations.
(*One of the Cadet range*)

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Enclosed type, compound filled, with standard laminations.
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Enclosed type, oil filled, with standard laminations.
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NEW TWO-WAY RADIO EQUIPMENT

Demonstrations of a new equipment, designed in Cambridge, have been given in London recently to representatives of Police and Fire Services, Local Authorities and Industrial Organisations. This equipment has been designed to defeat the chronic shortage of two-way radio channels.

Known as the Pye "Ranger" it is the solution to the frequency shortage which is hamstringing mobile radio users in Great Britain!

The new equipment operates on a channel spacing of only 25Kc/s—a quarter of the customary spacing—thus potentially quadrupling the number of mobile radio channels. Robust construction, excellent performance and carefully selected components make it capable of operating under arduous conditions and in any weather.

This mobile radio is designed for fitting in the dashboard of ordinary cars and vehicles. The price of the equipment, notwithstanding its many-times improved specification, is approximately the same as that of earlier equipments which it now replaces.

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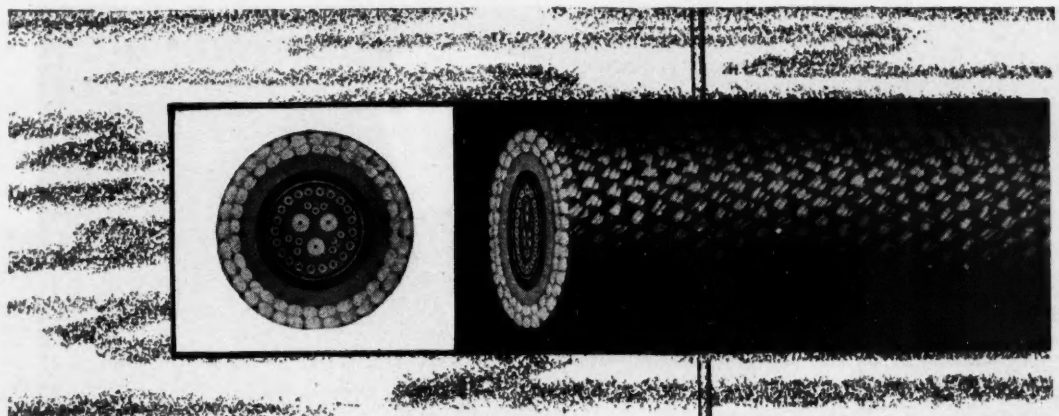

This cable carries weight

BICC Combined Camera Cable and Lifting Rope for underwater use.

This special multicore T/V camera cable is also used as a rope. It contains all the necessary electrical circuits and supports the full weight of the underwater T/V Camera by means of an overall hemp loom braid. It was designed and manufactured by BICC to meet the requirements of Messrs. Pye Ltd.

During recent trials the camera was repeatedly lowered and operated by this cable. Depths of 83 fathoms were reached and clear pictures obtained. Throughout the trials the cable was subjected to many severe tests. ★ALL CIRCUITS REMAINED INTACT.

BICC ARE ALWAYS PREPARED TO DESIGN AND MANUFACTURE CABLES TO MEET SPECIAL REQUIREMENTS

★ *It withstood a 2½ cwt. shock drop of 20 ft. out of water ; towed the camera at speeds up to 12 knots ; raised and lowered the camera at 250 ft. per minute over narrow diameter pulleys and capstan.*

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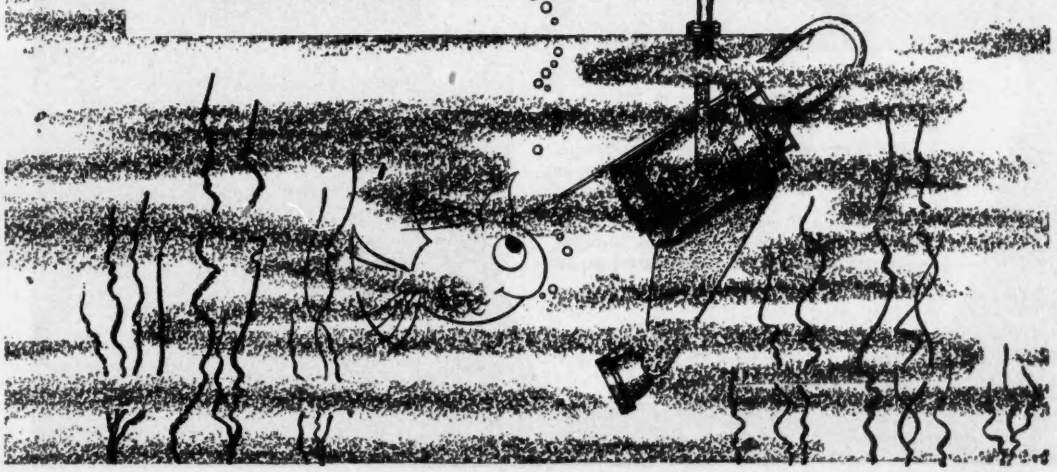

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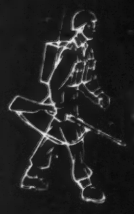
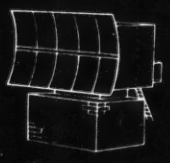
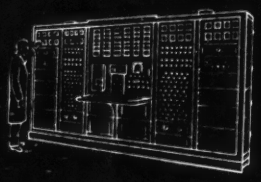
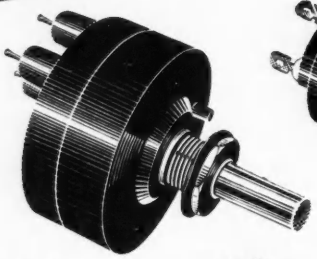
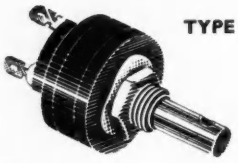
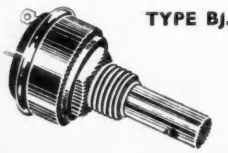






TYPE LH.

TYPE H.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TYPE H. 1½ watts — sealed. The most reliable potentiometer for Services and special requirements. Approved to RCL 122.

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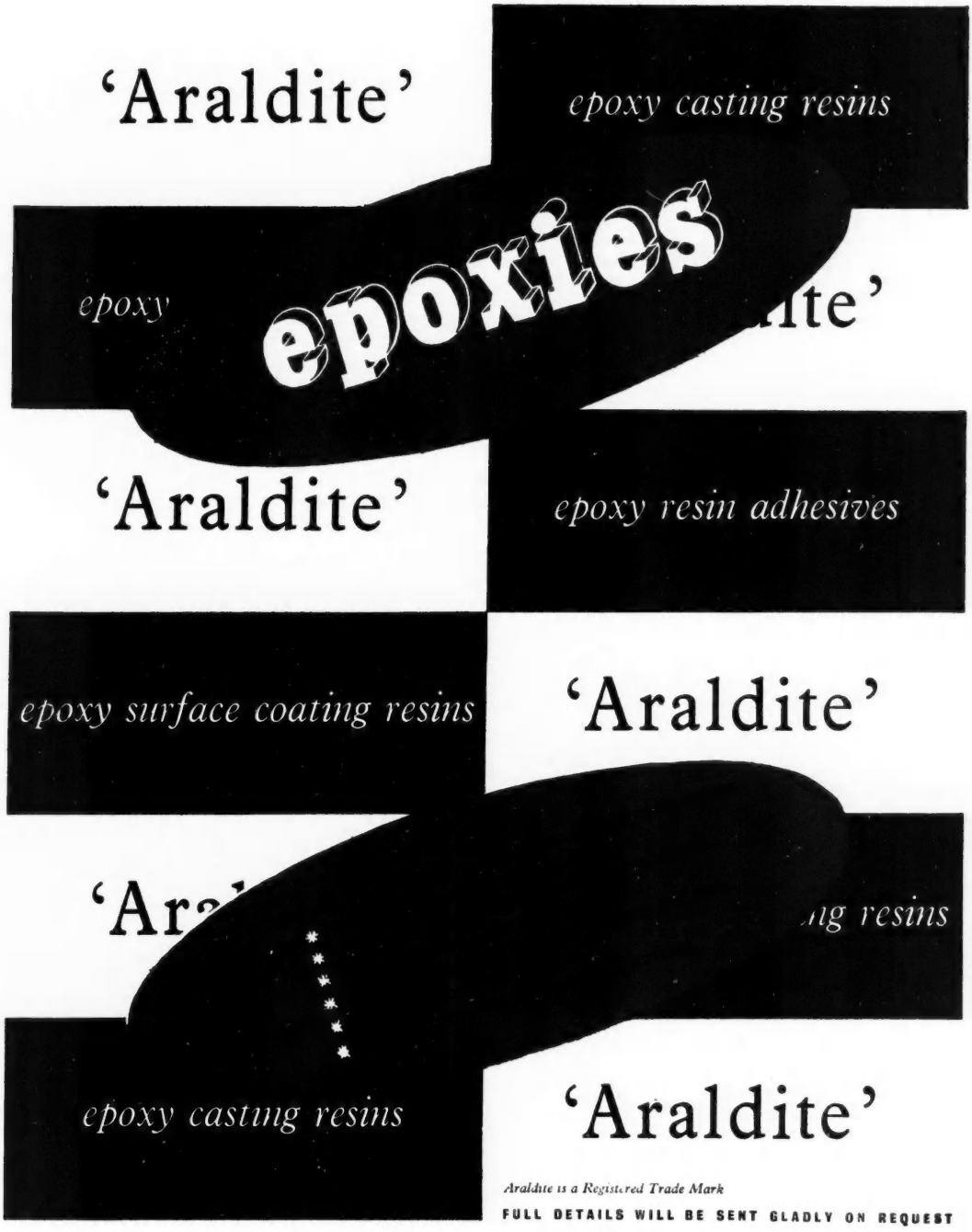

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Double Beam Tubes

Series D.6 and D.4

These tubes employ two independent electron guns. All eight deflector plates are separately connected and interplate screening ensures complete absence of intermodulation. The traces can be superimposed and each gun has a useful screen area of at least 100 mm. × 80 mm. Independent connections to each grid, cathode and focus electrode permit optimum conditions of operation for each gun and each of the beams may be brightness modulated. Sweep speeds of 100 cms./μsec. may be recorded using the D6B or D4B.

Type		D.6	D.4
Diameter		6 in.	4 in.
Overall lengths (mms.) ...		480	370
Sensitivity	X	700	400
mm./V. x VA_3	Y	700	350
Y capacity		4μμf	4μμf
Heater volts		6.3	6.3
VA_2 max. KV		5	5
VA_1 max. KV		2	2
VA_3 (VA_2=2KV) volts ...		300	300
Vg for cut-off (average) ...		—45	—45
Drive for 20μa I_B		20v	20v

Screens:

D6B — Blue for photographic or visual use.
D6G — Green for visual observations.
D6P — Medium persistence.
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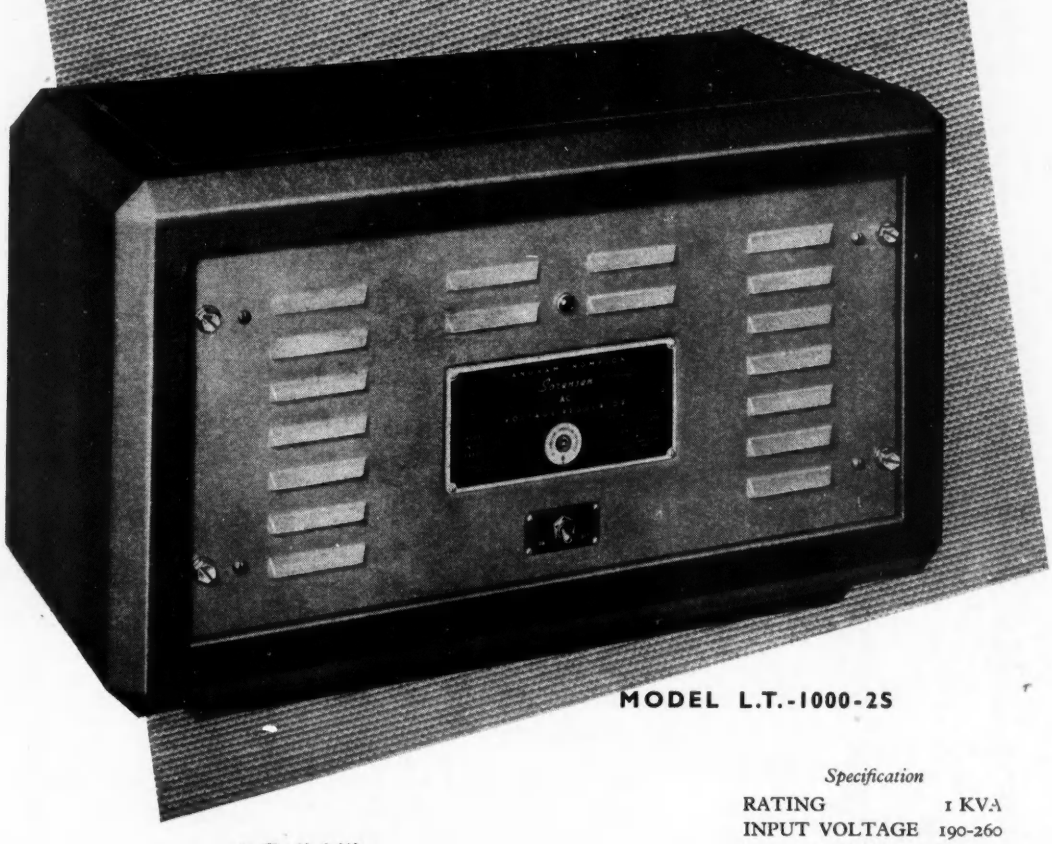

MODEL L.T.-1000-2S

- Reliability
- Exceptional accuracy
- Not affected by frequency
- Low distortion
- Fast response time
- No load to full load performance
- Excellent finish and fine workmanship throughout

Specification

RATING	1 KVA
INPUT VOLTAGE	190-260
INPUT FREQUENCY	50 c/s ±10%
OUTPUT VOLTAGE	220-240 (adjustable)
REGULATION ACCURACY	±0.1% nom.
RECOVERY TIME	0.1 secs.
HARMONIC DISTORTION	3% nom.
P.F. RANGE	Unity to 0.7
LOAD RANGE	No load to full load

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PROGRESS IN INSTRUMENTATION

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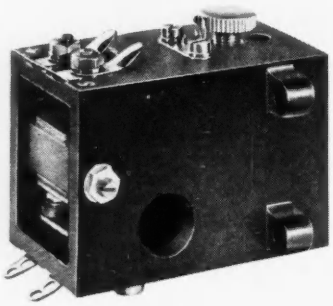
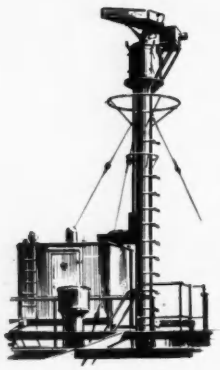
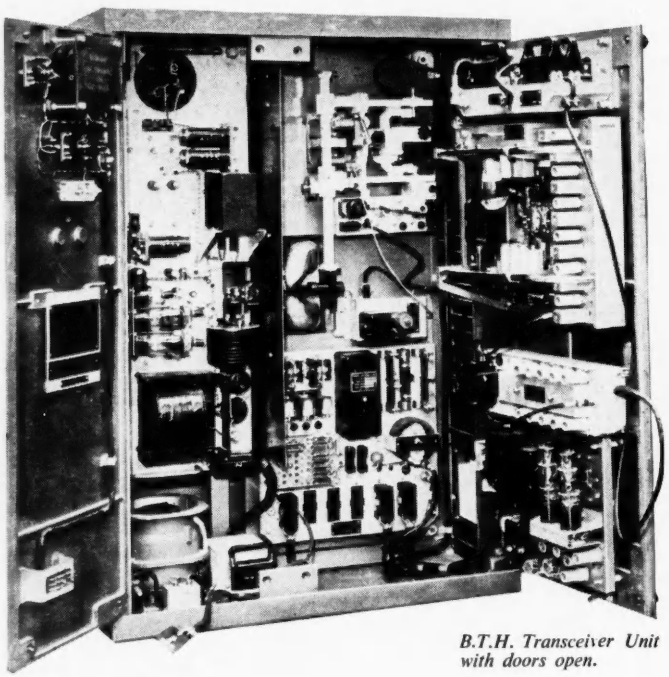
TIME DELAY
SWITCHES







B.T.H. Transceiver Unit with doors open.

These switches provide delays from 3 seconds to 6 minutes, unaffected by variations in ambient temperature. All the leading manufacturers of radar equipment use them for circuit protection, and there are a variety of other applications, including filament protection in electronic equipment and sequence switching. They are also used in many vital applications in the aircraft industry, where their undoubted reliability and consistency are especially valuable.

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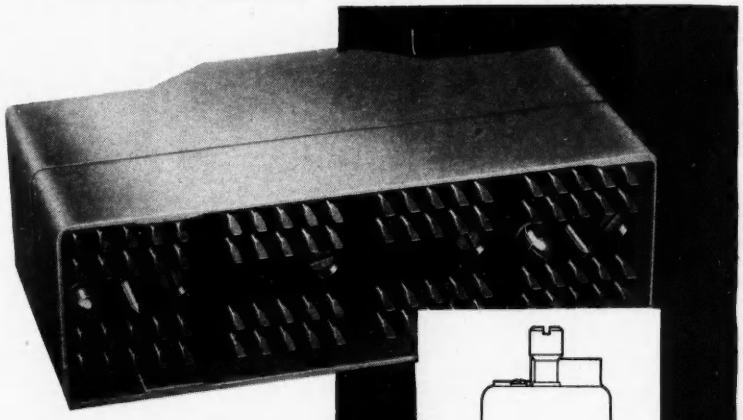

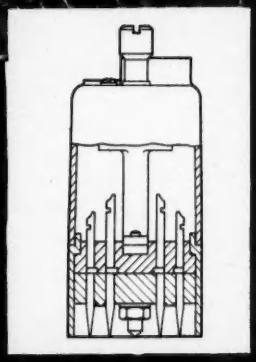

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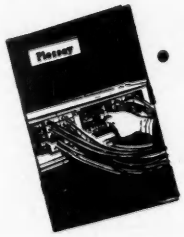
This Publication is available on request . . . if you would like further information regarding these and other multi-way connectors, Plessy Publication No. 741 is available to manufacturers free on request.



BRIEF SPECIFICATION

Working volts—250 v. D.C. — Insulation resistance 100 megohms at 500 v.

Maximum current —2 amps at 250 v. D.C. Contact resistance—1 milliohm.

Temperature range +70°C to −40°C.

The plug is secured in the socket by a central clamping screw. Cables are firmly clamped to avoid strain. Plug contacts are chisel-type blades which tend to make the plugs self-ejecting from the socket on disengagement.

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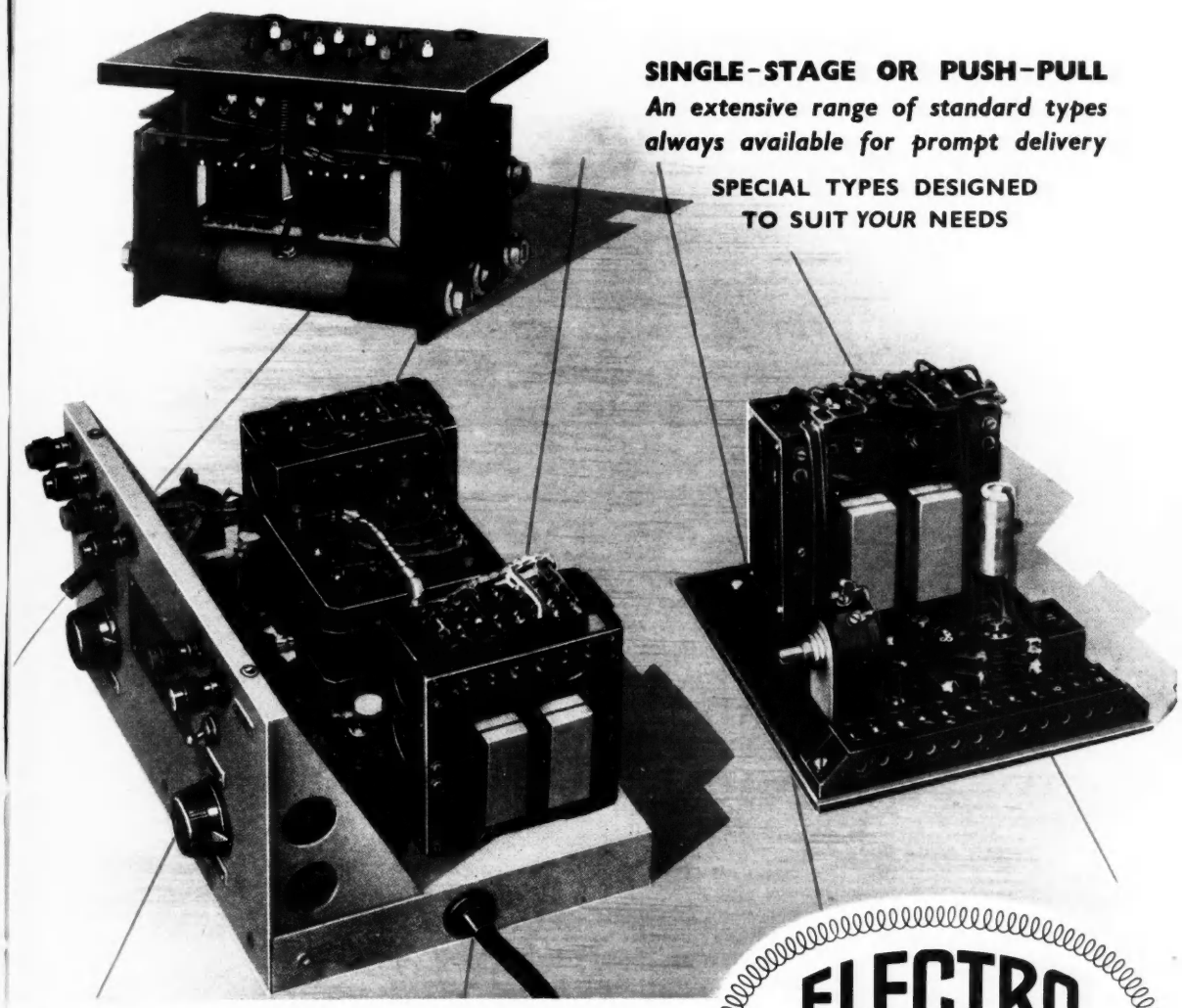

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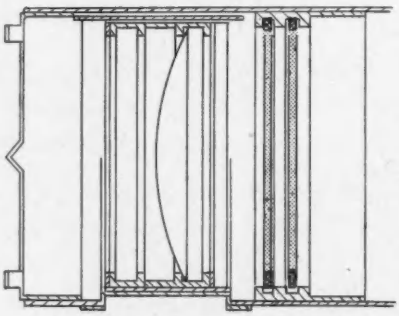

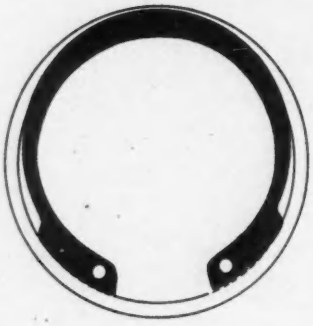

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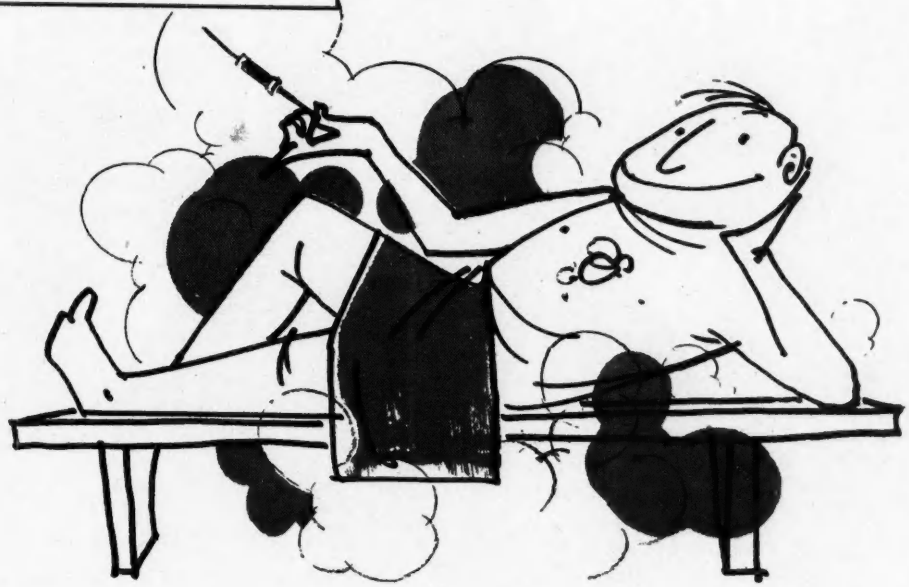

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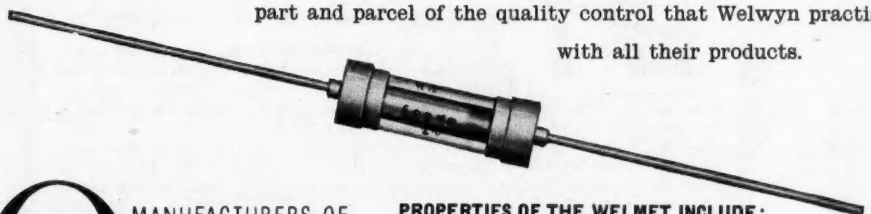

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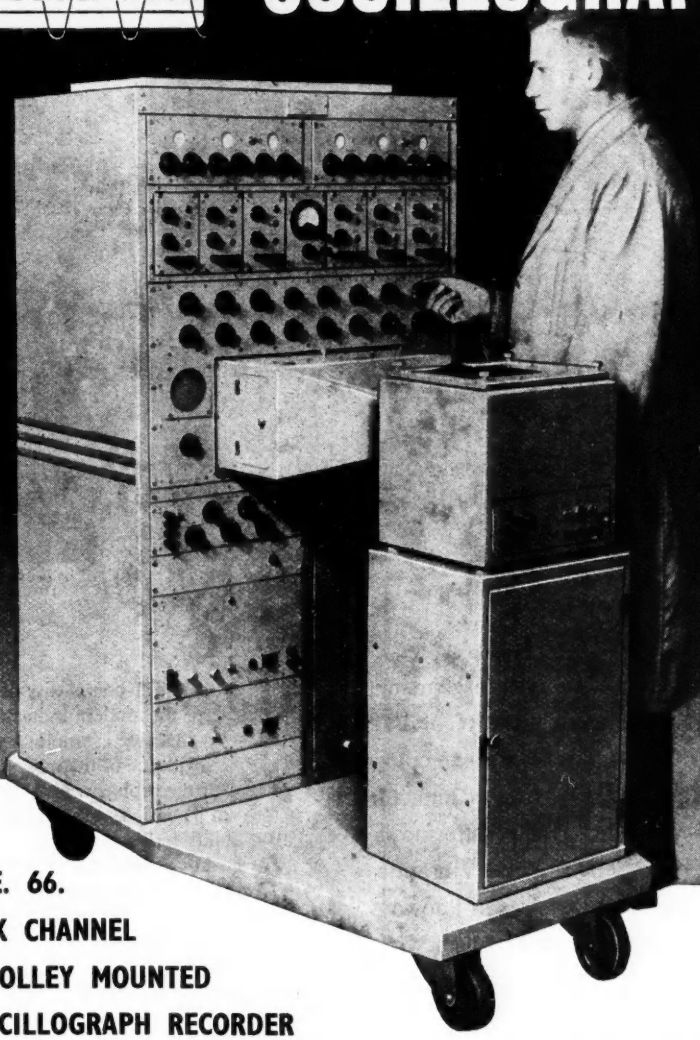

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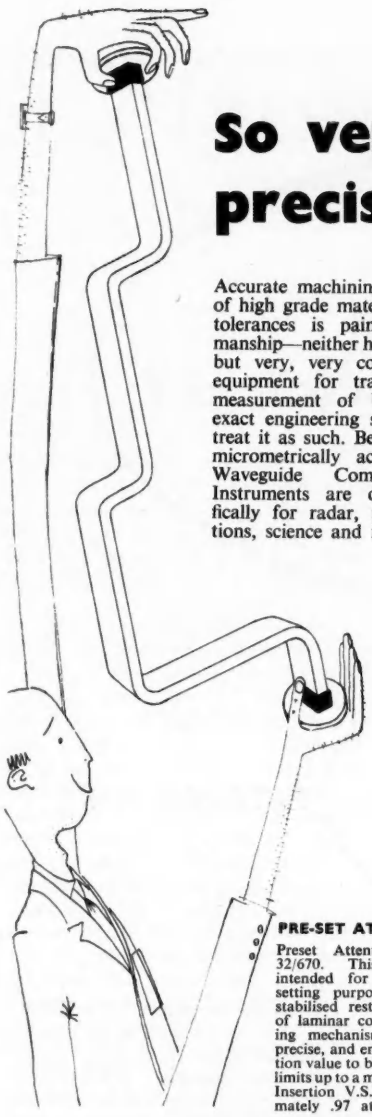

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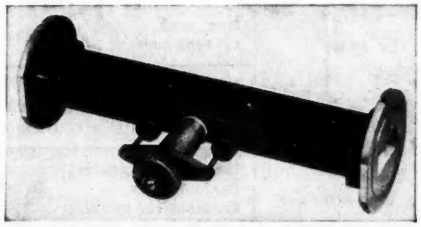

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ELECTRONIC ENGINEERING

VOL. 27 No. 334

DECEMBER 1955

Commentary

IN 1904 Rutherford wrote that "there is reason to believe that an enormous store of latent energy is resident in the atoms of radioactive elements—energy which is derived from the internal energy of the atoms . . . If it were possible to control at will the rate of disintegration of radioactive elements an enormous amount of energy could be obtained".

He was later to see his predictions verified, but in 1904 he could not have foreseen the subsequent developments of atomic energy which have derived from the work in the intervening fifty years.

If Rutherford would have been horrified by the events of 1945 when the atom bomb was first used as a military weapon, he would, we think, have read with much satisfaction that section dealing with the peaceful uses of atomic energy in the first annual report of the United Kingdom Atomic Energy Authority which has just been published.

The main emphasis of the peaceful uses of atomic energy is on the generation of electrical energy by the nuclear reactor and it is this development which was one of the principal reasons for the formation in July of last year of the United Kingdom Atomic Energy Authority under Sir Edwin Plowden.

The report is understandably vague with regard to those aspects of atomic energy which relate to military requirements, but on what is referred to as "the civil field" the report is both frank and factual.

After presenting the background history of atomic energy since the war, the report gives a most satisfactory picture of the Authority's activities since its formation, but the most disturbing feature is the alarming shortage of manpower of the right kind which, the report frankly states, is setting a limit to the Authority's progress.

As the report says, "Her Majesty's Government have never hesitated to furnish money needed for buildings, plant and equipment for the atomic energy programme; material shortages have never been insuperable; but the difficulty of recruiting and retaining sufficient skilled scientists, engineers and craftsmen has become acute throughout the ten years of the project and shows no signs of becoming easier".

The Authority has done what it can in the way of advertising its needs and by maintaining personal contact with universities, schools and technical colleges, but the results have been disappointing and the Authority has come to the conclusion that "there is a serious national shortage of most types of scientists and engineers and of many technical and craft grades, and that the Authority has not the same freedom of movement as industry in the matter of salaries".

The cold fact is that the growth of technological developments of all kinds has proceeded at such a pace in the post-war years that it is outstripping our manpower resources and we are suffering from an inflationary spiral where more and more advances are chasing a dwindling supply of skilled manpower. We are, in fact, trying to do too much in too short a time, yet if we are to survive as an economic power we simply cannot call a halt to research and development.

The complaint by the Authority that it cannot compete with industry as regards salaries is probably based on fact, but the granting of higher salaries provides no permanent solution. It only takes away a man from industry who more than likely is already contributing to industry's share of the atomic energy programme.

The announcement by the chemical, electrical and mechanical fields of industry of the formation of its plans to overcome the shortage is a step—but only a step. "Viewing with growing disquiet the shortage of scientists, mathematicians and technologists", the companies concerned have decided to assist the teaching of pure and applied mathematics in secondary schools and have set up an industrial trust of £1 500 000 to provide capital grants towards the building expansion, modernization and equipping of science buildings in independent and direct grant schools in Britain.

It does not, however, do anything to relieve the lack of science teachers in such schools, which lack is frequently put forward as one of the reasons why there is, in fact, so little interest in the scientific subjects at school.

The shortage is a long-term one and the solution can only be obtained it seems by going right back to the schools and "catching them young".

With the educational system as it now stands, there is no lack of opportunity for the child of adequate intelligence and no occasion to be "born to blush unseen and waste one's sweetness on the desert air".

The main problem is whether, with a decreasing population, we have a rising generation in sufficient numbers and capable of receiving adequate training to meet our future needs. If we have not, our future is very bleak.

16mm Tele-Recording for Sequential Television Systems

By V. B. Hulme*, M.A.

A system of tele-recording using continuous film motion through a shutterless gate is described. The camera motor speed is controlled by means of negative feedback components of phase, velocity and acceleration. A d.c. generator and pulse generator driven by the motor together with a phase-discriminator provide these components in the form of voltages.

A RECENT paper by Wood[1] on telerecording fundamentals gives an admirable presentation of the special features of continuous movement recording. The system described here which was developed for a sequential television system provides an interesting example of a continuous recording system in the 16mm field. Although the sequential nature of the television system puts this recorder outside the field of current broadcast television, interlacing is not a fundamental feature of television. It is rather interesting to note Wood's statement that the most economical means of recording a waveform on film is "to lay a variable density track across the film in closely spaced parallel lines" which exactly describes the method of picture recording described in the present article.

Continuous Movement Recording

Continuous film motion is employed mainly to avoid the loss of information which the pull-down period of the normal cine camera involves. Although an ultra-rapid pull-down period equal to, or less than, the frame blanking period is possible, the mechanical difficulties appear to be greater than those of a continuous recorder.

In order to clarify certain unconventional features of the design, the operation of the recording system will be described with reference to Figs. 1, 2, and 3.

The composite video signal is fed into a display unit to control the brightness of a fluorescent spot on the face of a c.r.t. (Fig. 1), the spot being caused to scan a line, as in normal television practice, in synchronism with line synchronizing pulses, but without the frame scan component. The image of the line is focused on a film in the camera by a lens, and the film is moved past the point of exposure continuously at a velocity $v=dF$ where d is the distance between sprocket holes and F is the frame recurrence frequency, since 16mm film has one sprocket hole per frame.

In the frame-scanning diagram (Fig. 2), the movement of the line image relative to the film is indicated by the straight line OC. This can be seen to be equivalent to the sum of waveforms A and B, where A represents the movement of the image due to the frame scan of a normal television raster and B, an intermittent film motion; the film being moved only during the frame-blanking period. The symbol η is used to denote the percentage of total frame-period available for picture information (i.e. unblanked).

The areas on the film exposed to active scanning are shown on the right, successive frames numbered 1, 2, 3, being exposed during the corresponding time intervals. The areas are scanned horizontally by the c.r.t. line scan and vertically by relative movement of film and line image.

With an intermittent system, the film motion must be synchronized with the frame-blanking for obvious reasons. With the continuous system, synchronism is desirable to fix the relation between image and sprocket holes on the film and to facilitate projection on a standard projector

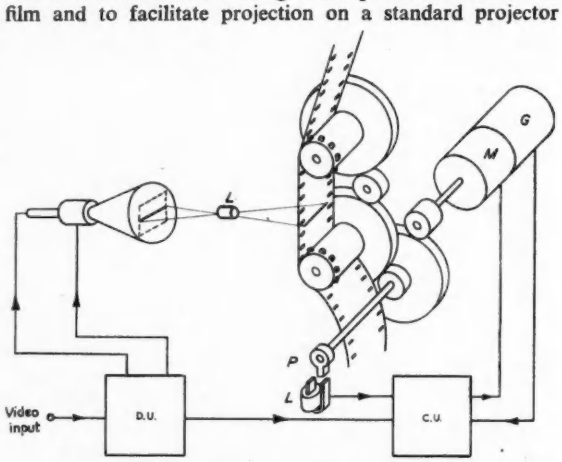


Fig. 1. Block diagram of recording system (simplified)

with intermittent film motion. Synchronism is effected by means of a pulse generator P (Fig. 1) producing pulses related in phase to the sprocket tooth of the sprocket driving the film. The pulses are fed to a motor control unit, together with pulses derived from the frame synchronizing signals from the display unit, and an output proportional to the phase difference is used to correct the speed and phase of the motor M.

There are two important disadvantages of the simple continuous recording system outlined above which may be effectively disposed of by combining the continuous film movement with a proportion of frame scan on the c.r.t. display. One disadvantage is the risk of burning the phosphor by concentration of the electron beam on a single line and the other is the difficulty of recording titles. Some form of titling is essential for identification of the recording in subsequent operations, e.g. editing. In Fig. 3, the line OE is the sum of a straight line representing a film velocity dF and an opposing frame scan waveform A. It is seen that the area of the film exposed to active scanning is reduced in the frame direction, the effective frame scan being $(1\text{-}S)\ d$, where S is the proportion of normal frame scan employed to form the raster. By reducing the line scan, the geometrical distortion of the aspect ratio is removed at the cost of a reduction in the size of the picture.

* *EMI Engineering Development Ltd.*

It is shown below that considerable reduction in energy per unit area on the tube face and hence increase in c.r.t. life is achieved by introducing a small amount of frame scan, say 5 per cent.

To record titles with a continuous film movement, a spot of constant brightness can be made to scan a transparent screen placed in front of the tube and carrying the titles in opaque or semi-opaque lettering.

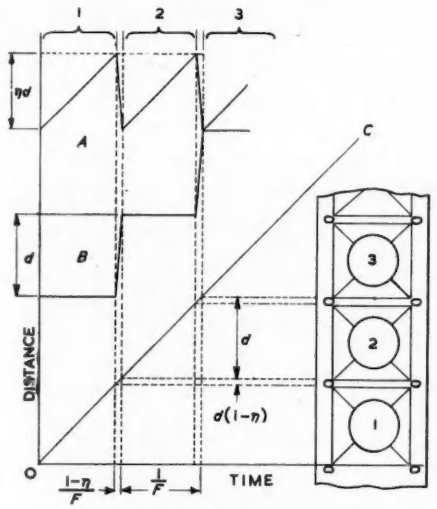


Fig. 2. Frame scanning diagram

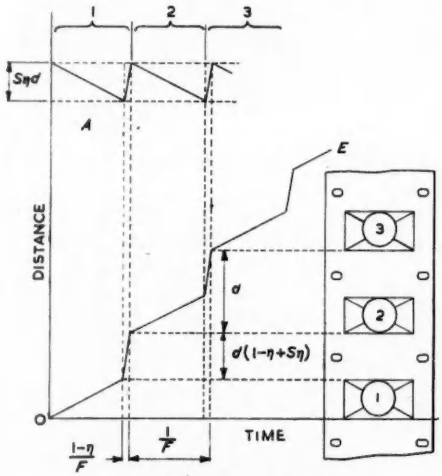


Fig. 3. Modified scanning diagram

For this purpose, all geometrical distortion will be avoided if the aspect ratio of the exposed area on the film matches that of the scanned area on the tube. It can be seen that this condition is satisfied if $S=1$—$S=\frac{1}{2}$, i.e. half normal frame scan is employed. Since the tube scan opposes the effective scan, the writing must be inverted. This is done by writing normally and turning the writing towards the tube face. It is interesting to observe that, with an opposing frame scan of amplitude $2d$ and frequency $F/2$, alternative frames of an interlaced picture could theoretically be recorded and exactly superimposed with a continuous film motion[2]. In practice, however, registration of the alternate frame is difficult.

It is necessary to compromise when choosing the proportion of frame scan S to be employed when recording. With S too small, the c.r.t. screen life can be reduced and, with S too large, the area of the picture is too greatly reduced with resultant loss of resolution. In fact, with 16mm film, very little reduction in the used area of the film can be tolerated as, in general, the emulsion is the limiting factor in the definition obtainable from the system. An exception to this might be made in the case of some film stocks having high resolving power, but these are insensitive and require a correspondingly brighter display.

For a given tube-brightness setting, the average brightness of the picture (light flux per unit area) will vary in inverse proportion with the frame scan but, assuming that lines are not overlapping, the maximum intensity at the centre of a line remains unchanged. As the lines begin to overlap, further reduction of the frame scan increases the maximum intensity in approximately inverse proportion until the scan S approaches the width of one line. The intensity then becomes that of a single line multiplied by the number of lines in a frame, since these are all superimposed when the frame scan is reduced to zero. While this reduction of scan results in high concentration of energy which may burn the tube, the total light-flux emitted per second is no greater and the film exposure remains the same as if full frame scan were employed with the film stationary. It is not, therefore, permissible to avoid tube damage by reducing the brightness as under exposure would result.

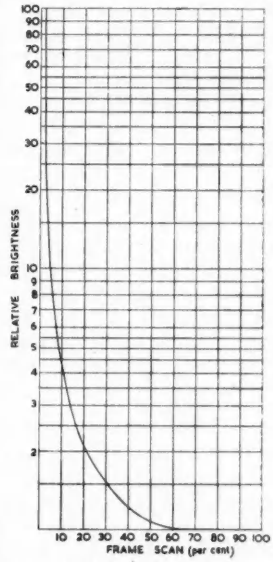


Fig. 4. Tube brightness against frame scan

The relation between average tube brightness and frame scan amplitude is illustrated by the curve of Fig. 4, which has been calculated on the basis that the lines begin to overlap at 50 per cent of normal frame scan. It can be seen that at 5 per cent of normal scan, the brightness is only ten times that occurring in a normal display, although the useful film area lost is only 2·5 per cent. This was found to be a satisfactory compromise.

A most important factor governing the choice of a c.r.t. for continuous recording is the decay characteristic of the afterglow. The effect of an excessive decay time is to destroy definition of the recorded image in the direction of the film movement, i.e. vertically. The common white television phosphor containing a mixture of yellow and blue sulphide is obviously useless for continuous recording. A blue silicate phosphor was chosen in preference to the zinc oxide, as used for flying spot scanning in telecine apparatus, as some afterglow results in greater efficiency and is not objectionable provided it falls below recording

level within one line period. The $CaTiSiO_4$ phosphor used has proved completely satisfactory; no afterglow affects being recorded with normal brightness levels, The requirement is, of course, much more critical with a flying spot scanner, when afterglow effects must be restricted to one horizontal picture element, usually with the aid of electrical compensation.

Apart from afterglow, other important tube qualities are brightness and resistance to screen burning. Although a projection-type tube might be preferable on the first score, a direct-view aluminized type was chosen, partly for greater life and reliability, and partly for convenience and availability of standard accessories. The cathode-ray tube, a type TA10, modified for a maximum anode voltage of 10kV and with a blue silicate phosphor screen, was found to have an adequate light output. A flat tube face is not essential in the absence of appreciable frame scan.

Physical Layout

The recorder rack assembly shown in the photograph, Fig. 5, is a complete two-channel recording unit. The two outer bays each contain, from top to bottom, a display unit, a mirror viewing unit, camera, camera-motor power unit and display e.h.t. unit. The central bay contains the two camera-motor control units, four stabilized h.t. units for the display and control units and a locker whose doors open downward to form a small writing table.

For convenience in rack mounting, the tube axis and camera optical axis are vertical, the tube being mounted face downwards to minimize risk of damage and to prevent accumulation of dust. In order to preserve maximum shadow detail and to exclude external light, a tunnel extends from the tube face to the camera lens. A hinged mirror fitted to the wall of the tunnel nearest the front panel allows a visual examination of the display to be made but the image cannot be recorded while it is being visually examined.

THE DISPLAY UNIT

The display unit has several features worth mentioning for their bearing on the continuous method of recording. Since negligible frame scan is used during recording, no attempt has been made to provide optical means for monitoring the picture on the recording tube, but some attention has been given to the problems of simplifying the operator's task. A three position switch allows titling, recording and setting-up operations by controlling the amount of frame scan and operating interlock circuits; the latter are designed to prevent incorrect operation of the camera, with particular reference to the titling facility.

Titling is carried out, as previously mentioned, by applying 50 per cent frame scan in a direction to oppose the scanning effect of the continuously moving film, and the tube is used somewhat as a flying spot scanner to reproduce titles and other identification marks, which may be written with a chinagraph pencil on a perspex screen placed immediately in front of the tube. For this purpose a slot is provided in the cast aluminium tube support and in the front panel, into which the perspex screen can be inserted Thus when the titling facility is required, half the normal frame scan is applied, a suitable d.c. bias is substituted for the video input to the tube, and microswitches in the camera motor circuit permit operation of the camera only when the titling screen is in position. The synchronizing input is also switched for direct synchronism of the frame scan by the camera, so that external signals are not required for this operation, and a warning indicator lamp is lit on the front panel.

For normal recording, the necessary small amount of frame scan required to prevent the burning of the tube screen is provided and the microswitches are set to prevent operation until the titling screen is removed from the slot. For setting up purposes, full frame scan is provided and the camera motor power is disconnected.

The brightness and contrast controls are calibrated, since both these adjustments are critical for correct exposure of the film and, hence, for correct tone reproduction. Fortunately, a sensitive and accurate monitor for the tube brightness is readily available in the form of a beam current

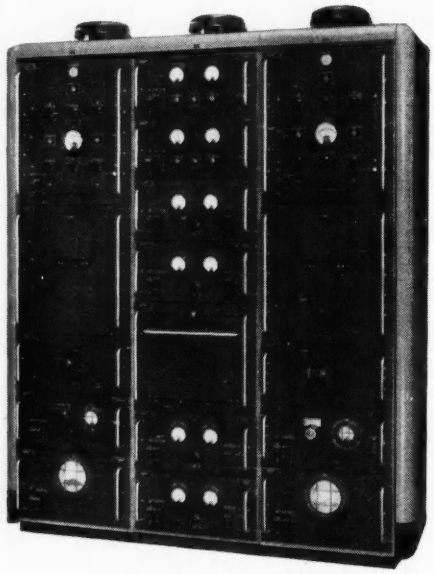


Fig. 5. Recorder rack assembly

meter since the relation between brightness and beam current is almost completely linear.

To ensure that the brightness control remains independent of the contrast and to stabilize the black level, a black level clamp circuit is provided. Fig. 6 shows a simplified circuit diagram in which V_2 and V_{3a} are video amplifiers and V_{3b} a cathode-follower which provides a low output impedance for rapid charging of the d.c. blocking capacitor C_1. The diodes V_4, V_5 form a clamp circuit which connects the c.r.t. grid virtually to earth when the diodes conduct; this occurs on the application of a negative pulse to the grid of the switching valve V_6. The negative pulse is derived from a pulse generator (not shown) which is triggered by pulses differentiated from the back edge of the line synchronizing pulses, so that the diodes conduct during the "back porch" interval of the line period, corresponding to black level in the video waveform, and maintain the charge on C_1 so that the tube grid potential is always zero during this interval. The contrast control is set to zero for adjustment of the brightness control VR_1 to give, say, 0·5μA beam current. The contrast is then set normally without the necessity for further adjustment to brightness; it is maintained at the black level by the clamp circuit.

For monitoring the peak value of the brightness, a switch

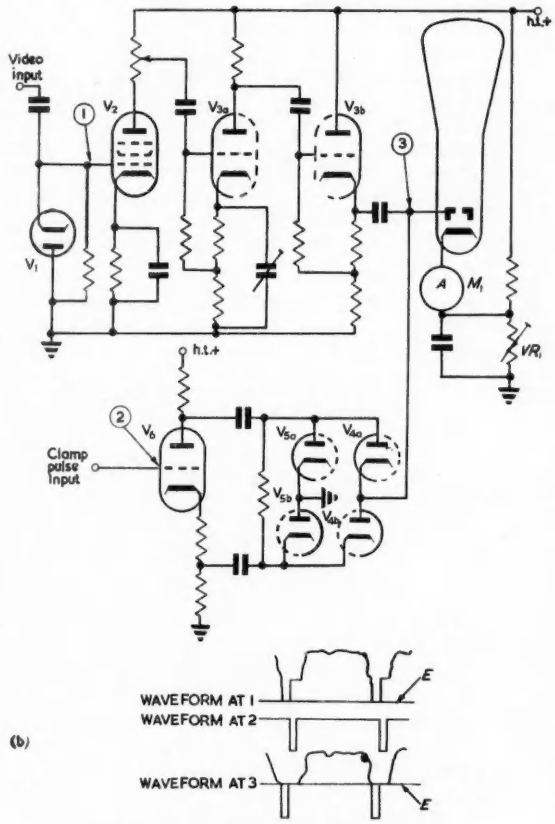
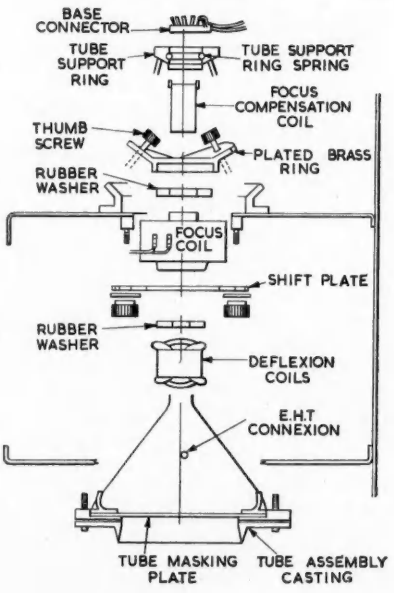


Fig. 6. Video amplifier and black level clamp

Fig. 7. Exploded assembly of c.r.t. components in camera display



is provided which converts the meter M_1 to a peak voltmeter to measure the voltage developed across a load resistor in the cathode circuit of the c.r.t.

The tube is an E.M.I. TA10 tetrode, modified in that it has a blue silicate phosphor screen which is backed with an aluminized coating. An e.h.t. potential of 9kV is used, giving a screen brightness of 6 foot-lamberts at 100μA beam current. Current for the focusing electromagnet is supplied by a tetrode valve which is fed with waveforms of line and frame frequency; these waveforms are parabolic to compensate for deflexion defocusing. A small subsidiary focus coil having low self capacitance is used in series with the main coil for the line focus compensation. An exploded view of the c.r.t. components is given in Fig. 7.

The Camera

A general view of the camera unit is given in the photograph, Fig. 8; Fig. 9 shows a close-up of the camera light box and the path followed by the film from the feed magazine through the light box to the take-up magazine.

Before giving a detailed description of the camera mechanism, it may be as well to consider the design problem posed by the simultaneous requirement of continuous movement recording and compatibility with intermittent projection on a standard projector; this is rather more difficult that that of sound-on-film recording. In sound recording, comparatively large phase errors are tolerable provided the rate of phase change is restricted, consequently large compliances may be employed to depress the cut-off frequency of the low-pass mechanical filter controlling the film speed. In picture recording, phase errors result in faulty framing when projected, and phase modulation greater than 0·1 per cent at frequencies as low as 1 or 2c/s shows up as a concertina effect on the vertical dimensions of the picture which is more objectionable than the random errors normally present in intermittent projection. Assuming a perfect projector, such errors may amount to $\pm$0·16 per cent due to manufacturing tolerances on the film sprocket holes alone.

The basic elements of a typical sound recorder filter system[3] are shown in Fig. 10 together with a simple electrical analogy. The sprockets drive the film and maintain a constant loop length in the filter system, and are represented by the generator E; the jockey arms and spring control the tension in the loop and provide the compliance L in the filter system. The inertia drum is driven by the film and is rigidly coupled to a flywheel; this provides the inertia represented by C while the damping is provided by the dashpot which is represented by R. The velocity of the film at the drum is represented by E_o and the system exhibits the characteristics of a simple low-pass filter.

This basic scheme has been used, with suitable amendments, in the camera light box and the completed filter is shown in Fig. 9. In order to limit phase errors, the length of film between the sprockets has been reduced to the minimum necessary for adequate filtering of sprocket flutter. The spring-loaded jockey arms supply most of the compliance and provide the tension necessary for a friction drive on the inertia drum, which is coupled by a common shaft to a flywheel in the gear box. The film is exposed on this drum. The tension in the film loop on either side of the drum is controlled by ratchets which secure one end of the coiled springs on the jockey arms. The parameters of the mechanical filter are not critical, and it was found that incidental friction provided adequate damping. The flywheel dimensions were calculated to pro-

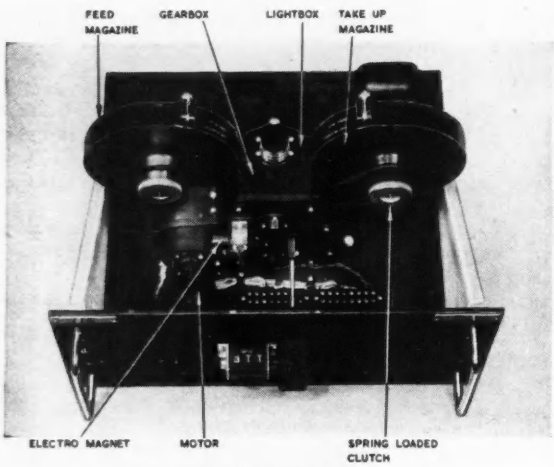


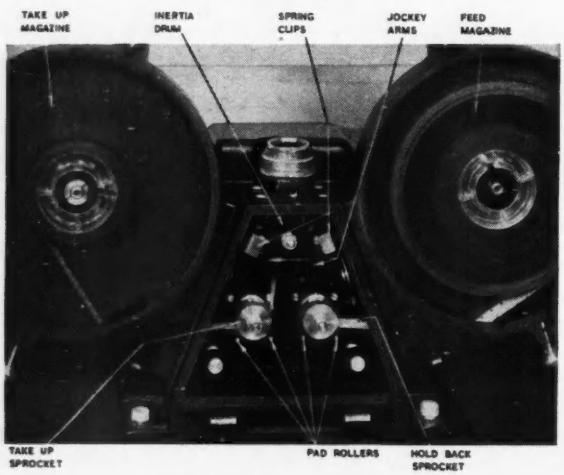
Fig. 8. Camera unit

vide the maximum inertia compatible with acceleration to full speed in two or three seconds.

Fig. 9 shows the interior of the light box and magazines, and the path of the film is illustrated. The film leaves the feed magazine via a labyrinth light trap of three idling rollers and passes round the hold-back sprocket, the inertia drum and take-up sprocket; to facilitate threading the film, the pad rollers and jockey arms can be held in a retracted position by means of ball catches. The sprockets are to SMPTE standards and have teeth on one end only, thus single or double perforated film can be used. The sprocket for the feed magazine is designed as a hold-back sprocket and that for the take-up magazine as a drive sprocket; this technique is necessary to achieve perfect engagement between the teeth and the film holes and minimum flutter.

The motor, which is mounted on the outside of the gear box is a d.c. motor generator (Velodyne 88X), providing a maximum torque of 2·1oz. in. The speed, which is controlled by a field winding rated at 25mA d.c. maximum, may be critically adjusted over the range 20 to 9 000rev/min by using the generator output voltage, which is proportional to speed, in a negative feed-back loop whose

Fig. 9. Camera light box



amplifier feeds the field windings. The precise phase of the film drive with relation to the scan on the c.r.t. is controlled by means of a mild steel arm rotating on an intershaft geared to the sprocket shaft with an 8:1 ratio, since the sprockets have eight teeth. The arm passes close to a gap in a electromagnet every time a sprocket tooth passes through a certain phase and thus produces a pulse which is fed to a phase discriminator in the motor control unit. The phase is maintained constant with reference to that of the television frame pulse. The details of this operation are given in the next section.

Camera Motor Control

The camera drive and control gear is designed to achieve economy of weight, space and power consumption and the velodyne motor is most appropriate for this purpose; the control unit, in fact, weighs 30lb, is 8¾in deep and consumes less than 100W.

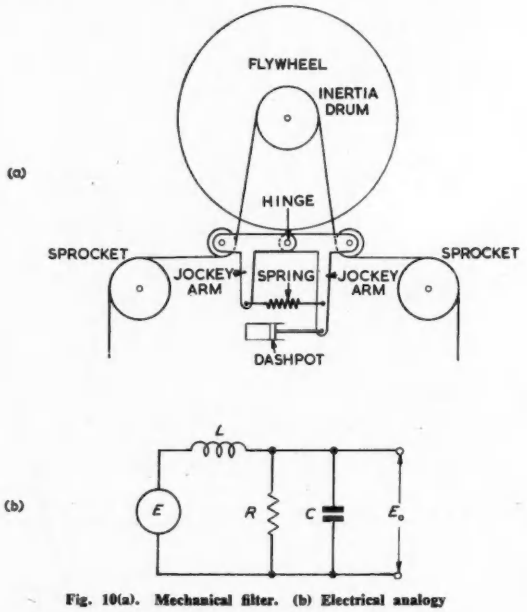


Fig. 10(a). Mechanical filter. (b) Electrical analogy

The basic circuit of the control unit is shown in Fig. 11. The velodyne 88X, consists of a d.c. motor M and a d.c. generator G, coupled together on a common shaft[4]. The power required to drive the motor is supplied to its armature winding from a 24V d.c. supply via the lamp LP_1; S_1 is the motor on-off switch. The motor field windings, which are used to control the speed of the motor, take a maximum current of the order of 20mA and are connected between the anodes of the cathode-coupled control valves V_4, V_5. Since the motor is required to rotate in one direction only, the anode loads R_1, R_2 are adjusted for an initial field current of 9 to 10mA when the motor is at rest and the grids of V_4, V_5 are at ground potential, the potential of V_5 grid being limited by the diode V_8.

The generator, whose field current is supplied from the h.t. line, produces a d.c. voltage proportional to the generator field current and the shaft speed. As the motor accelerates, the voltage generated increases and, when it exceeds the "delay" voltage set by VR_1, it is applied to the control valve V_5 so as to reduce the motor field current. A negative feedback loop is thus formed, and the motor speed is

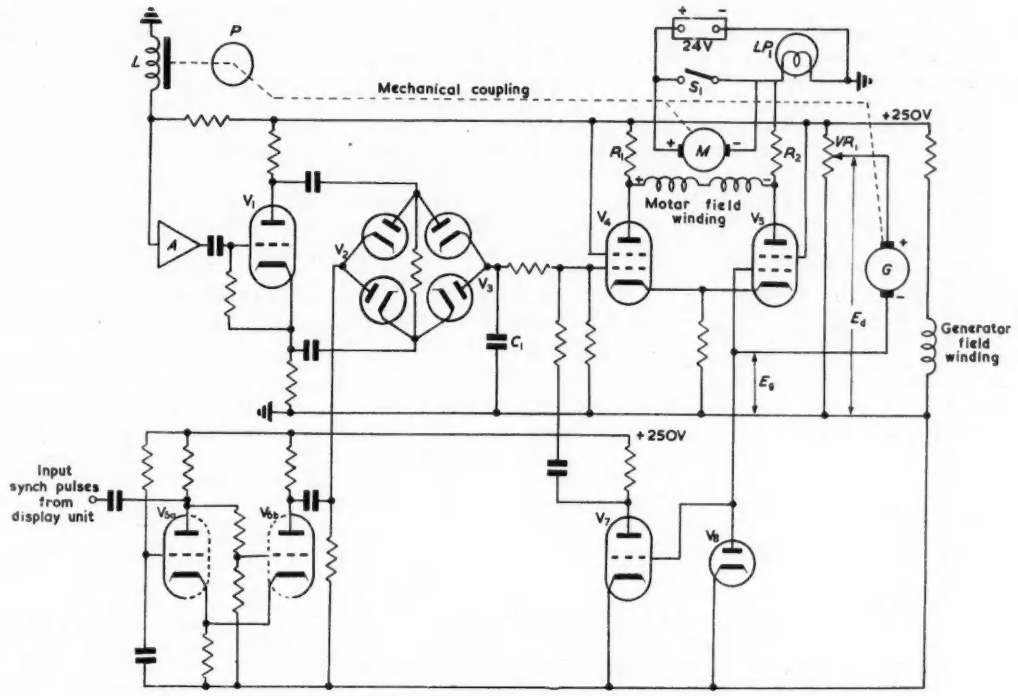


Fig. 11. Simplified camera motor control circuits

stabilized to give a generator output voltage which exceeds the "delay" voltage by a fraction of the grid base of V_5 as defined by the conditions required for equilibrium.

The required grid voltage is:

$$E_g = \frac{E_d}{1+Af}$$

where E_d is the delay voltage, A is the function relating motor speed to E_g and f is a constant relating generator output to speed. Substituting the speed v for $A.E_g$, and v/A for E_g, in the above equation:

$$v = E_d \frac{A}{1+Af}$$

and, if $Af \gg 1$,

$$v = E_d/f$$

i.e. the motor speed is controlled solely by the delay voltage setting

The motor generator shaft is geared to the mild steel arm which rotates past the air-gap in the flux path of coil L (the electromagnet of Fig. 8). The d.c. flux is modulated by the variation in the reluctance of the magnetic circuit when the arm passes the gap, so producing a voltage pulse across the coil which is fed via the amplifier A and phase splitter V_1 to close the four-diode switch V_2, V_3. The switch also receives a symmetrical square wave from V_{6b} which is triggered by the frame synchronizing pulse from the display unit and, when the switch is closed by the pulse from L, C_1 is charged to the instantaneous value of the potential at the output of V_{6b}. When the recurrence of the switching pulse is equal to, or an integral submultiple of, the frame frequency, the potential at C_1 will depend only on the relative phases of the pulse and the waveform. The circuit thus forms a phase discriminator, the output of which is fed to the control valves V_4 and V_5.

The combination of motor, pulse generator, phase discriminator and control valve, forms a phase-sensitive feedback loop. When the pulse coincides with the negative-going transition of the square-wave, the feedback is negative and the circuit is stable. External forces tending to displace the phase of the motor produce a voltage at C_1, proportional to the phase error, which counteracts this tendency. When the motor is correctly phased, there is no potential across C_1.

When the pulse coincides with the positive going transition, the feedback is positive and the motor phase is unstable. It may move in either direction, and a discriminator output is then obtained which brings the phase into synchronism with the negative-going transition, and hence with the frame synchronizing pulses.

The inertia of the motor produces a time lag in the transient response which will result in hunting if the loop gain is sufficient. As the loop gain is necessarily high for good phase sensitivity, it is necessary to damp the transient response by adding, to the phase control voltage, a voltage proportional to acceleration. This voltage is derived by differentiation of the velocity voltage from the generator G, after amplification by V_7, and is phased to oppose rapid changes of motor speed. This forms another negative feedback loop which opposes changes in motor speed and is desirable on this account alone in a continuous film drive, quite apart from its effect on the phase lock. The phase discriminator does not operate continuously, but samples the phase at frame synchronizing intervals; the velocity of the motor between phase sampling points is controlled

mainly by the inertia of the motor and by acceleration feedback.

The phase control circuit does not operate until the motor reaches the correct speed, and to avoid spurious outputs from the phase discriminator while starting, the switching pulse is gated by cathode bias of the first valve in the pulse amplifier *A*. The bias is applied by a cathode-follower which is d.c. coupled to the positive voltage from VR_1 via the generator armature winding *G*. When the motor reaches the correct speed, the negative output from the generator cuts off the cathode-follower and removes the bias from the pulse amplifier valve. The pulse amplifier includes shaping and limiting circuits, so that the pulse fed to the phase-splitter valve V_1 is of constant amplitude and duration, regardless of motor speed.

The voltage output from the discriminator is proportional to the phase error, and is monitored by a valve voltmeter for the convenience of the operator; full scale deflexion representing a phase error of 0·8msec. The voltage output of the generator is also monitored to indicate the motor speed.

An advantage of this form of camera drive is its versatility. The camera may be adjusted to operate at any speed up to 18in per second, with or without synchronism.

Performance

The time required for the camera to reach full speed from a stationary condition and to become synchronized is between two and three seconds. Should the television signal fail, the motor coasts at normal speed, since the discriminator output is zero when synchronized with zero phase error or in the absence of signal. The normal speed is maintained without synchronization by the d.c. negative velocity feedback, while the a.c. acceleration feedback prevents changes in speed due to random friction, until the synchronizing signal is restored. The camera then returns to phase synchronizm in a fraction of a second. The system has proved exceedingly stable; over periods of several months it has been unnecessary to adjust the synchronizing controls.

The resolution of the recording system is limited by that of the film itself. The photographic aspect is conventional, except when using comparatively slow, high-definition film stock. In the latter case, it is necessary to record at low contrast, with the black level set to one-third peak brightness, and peak white set to normal peak brightness. The negative is then developed to a high gamma (2·5 to 2.·7), using a positive bath. In this way, a normal range of density is obtained on a negative which must otherwise be under-exposed, and a tolerable reproduction of tone values is obtained.

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Crystal Palace Television Station

The Television Advisory Committee has informed the Postmaster-General that the best technical solution of the problem of siting television stations in the London area is a single tower to carry the aerials for all the television services of the BBC and ITA. The BBC has accordingly agreed to make provision for the ITA's requirements on the tower now in course of erection by the BBC at its new television station at Crystal Palace. The BBC's offer has been welcomed by the General Post Office, which is responsible for approving the sites of all BBC and ITA stations, and by the ITA itself. The ITA is at present negotiating with the L.C.C. to acquire land near the base of the tower for the erection of a building to house a new television station which will replace the temporary station now in service at Croydon.

The new arrangements will involve halving the size of the BBC's Band I aerial. The top 250ft of the tower will have to be redesigned and this will delay its completion by 18 months. It will not therefore be possible for the new tower to be brought into service early next year as had been planned. However, in order that the new high-power transmitter which is being installed at Crystal Palace may be brought into service as soon as possible, the BBC will erect a temporary mast and aerial, 250ft high. This temporary mast and aerial system will be capable of a radiated power of 60kW which the BBC had hoped to be able to radiate initially from Crystal Palace.

The Corporation has decided to make this arrangement in order to achieve co-siting of the BBC and ITA stations in London, which has been recommended by the Television Advisory Committee as a means of giving the best reception to viewers of both services. When the new tower and aerial system in its new form come into service about May 1957, the BBC will be able to raise the power of its transmission to 125kW. Later on a further increase to nearly 500kW, the maximum permitted by international regulations, is planned.

The ITA hopes to begin transmitting from the new tower at the Crystal Palace during 1957.

The BBC have awarded further contracts to Marconi's Wireless Telegraph Co. Ltd. for work on the Crystal Palace television station.

These call for the erection of a 250ft mast, together with an aerial and feeder system, and for the design, construction, and installation of a special catwalk.

This latter is rendered necessary because, for technical reasons, the mast has had to be built in the middle of a disused reservoir; the catwalk will carry the feeders across to the base of the mast.

Due to the unusual nature of the siting, the work involved represented a radical departure from routine. First, the water had to be drained and a number of carp transferred to a pond in the Crystal Palace grounds. This done, mud to a depth of several feet was removed from an area to enable the mast foundations to be laid.

Although a rumour—subsequently disproved—of the presence of an unexploded German bomb caused a certain delay in progress, the foundations have gone in, and work on the mast is virtually complete.

For the purpose, use is being made of the Marconi mast which formerly carried the temporary aerial at Northern Ireland's television station. This aerial was recently replaced by a permanent structure, and consequently became redundant. It was dismantled by Marconi's in under three weeks.

The re-erection of the mast at Crystal Palace is being carried out for the BBC and Marconi's by British Insulated Callender's Construction Co. Ltd. It will be in use there until the permanent 640ft tower is completed.

The two pairs of Marconi vision and sound transmitters for the Crystal Palace station are already on site, and in an advanced stage of installation.

The Electron Gun of the Cathode-ray Tube

Tetrode or Triode?

By J. A. Darbyshire*, M.Sc., Ph.D., F.Inst.P., A.M.I.E.E.

An attempt is made to assess the relative merits of the tetrode and triode types of electron guns as used for cathode-ray tubes. The discussion covers matters relating to spot size, beam angle, cathode loading, and other relevant features.

It will be seen that, for certain applications, the triode gun has some characteristics which are more desirable than those of the tetrode. In most of the normal television applications of cathode-ray tubes, however, the tetrode type of gun would be preferred.

IT is intended here to review some of the main features of the tetrode gun and to compare them with those of the triode gun. In this way it is possible to emphasize the fundamental differences in the behaviour of these two guns and to indicate the advantages which the tetrode can claim when it is compared with the triode.

The Triode Gun

The triode gun is shown diagrammatically in Fig. 1.

Electrons leave the cathode O and pass through a cross-over region at C shortly after passing through L_1.

This crossover point C is then focused on the luminescent screen by means of L_3 to form a spot S.

The manner in which the crossover is formed at the

Fig. 1. The triode gun

point C is very complicated and is not thoroughly understood at the present time. The following description is in accordance with the principles of geometrical optics and electron optics. The electrons leaving the cathode pass into a lens which can be regarded as represented by a surface convex towards the cathode and of very high refractive index. In such a case all electrons from the cathode pass through what is effectively a single point which is situated at the effective centre of curvature of the refracting surface and is also the focal point of the lens for parallel light. This image point is called the crossover and it is usually much smaller in diameter than the effective diameter of the cathode, because it is closer to the effective position of this first lens L_1 than the cathode itself. The crossover diameter is usually found to be approximately one-tenth of that of the emitting surface of the cathode.

The above explanation as to the formation of the crossover is usually quite sufficient to form the basis of any discussion on the design of cathode-ray tubes. It is certainly quite sufficient for all the discussions in this article. It is desirable, however, to indicate briefly a further elaboration of the theory of the formation of the crossover which is often believed to be a more correct description of what actually takes place in this complicated immersion system.

The crossover point formed in the manner just indicated is probably developed so that it appears just inside another refracting surface which is itself divergent[1]. This means that the rays which leave this second divergent lens appear to come from a virtual image of the crossover which is situated some distance behind the cathode itself.

This means that the focusing lens receives its rays from a virtual image of the crossover situated a good deal further away than the position at which the original crossover would have been formed if it had not been for the presence of the divergent component in the complete immersion lens.

The Tetrode Gun

The tetrode gun is shown diagrammatically in Fig. 2.

Electrons leave the cathode O and pass through a cross-

Fig. 2. The tetrode gun

over region at C. The lens L_2 is of considerably less power than the lens L_3 of the triode. This lens L_2 collects the beam after passing through the c ossover and serves to make the beam emerging from the crossover less divergent than in the case of the triode. The beam is converged by the final lens L_3 which serves to form an image of the crossover on the luminescent screen. This explanation of the optical system of the tetrode is based on the simple theory of the formation of a real crossover just in front of lens L_1 and which itself forms a real object for the remainder of the optical system which involves L_2 and L_3.

The more complicated theory of the formation of the crossover as outlined in the case of the triode could also be used in giving a full description of the mode of operation of the tetrode type of gun.

The fundamental feature of the tetrode type of gun is that it has a smaller beam width than the triode in the region of the scan coils. This comes about because the beam diverging from the crossover is focused to some extent by the L_1L_2 lens and therefore the beam is fairly narrow when it passes through the final lens L_3. This final lens is nearly always a magnetic lens in the case of both triode and tetrode type of gun in cases where the cathode-ray tube has been designed for television purposes.

If it is desired to obtain a narrow beam in the triode it is necessary to move the lens L_3 to a position quite close to the modulator. It is not possible to construct

* *Physical Laboratory, Ferranti Ltd.*

a magnetic lens of sufficient power and whose action could be sufficiently sharply localized in this region so as to simulate the performance of the normal tetrode gun. It is evident that it is better to arrange for an electrostatic lens to be put in position close to the crossover in such a manner that the lens gives rise to a considerable degree of convergence of the rays from the crossover and directs them towards the main focusing lens L_3.

Magnification

The overall magnification is given by:

$$M = \theta_c/\theta_s$$

Where θ_c is the semi-angle of divergence from the crossover and θ_s is the semi-angle of convergence on to the spot on the screen.

This expression for M holds good, no matter whether the result has been obtained by means of one or by means of more than one lens.

The formula $M = (\theta_c/\theta_s)$ does not take into account the difference in refractive index in the image and object spaces.

If n_c represents the refractive index near to the crossover and n_s represents the refractive index at the screen, the formula for M becomes:

$$M = (\theta_c/\theta_s) \cdot (n_c/n_s) \quad \ldots\ldots\ldots\ldots (1)$$

This leads directly to the usual form of expression

$$\text{Spot size} = \text{crossover} \times M \times \sqrt{(V_c'/V_s')}$$

where V_c' is the potential at the crossover and V_s' is the potential at the screen.

The system of lenses in the tetrode means that it is possible to start off with a certain value of θ_c and finish up with a smaller value of θ_s than in the case of the triode. The ratio θ_c/θ_s is always greater in the case of the tetrode than the triode, and the magnification of the spot in the tetrode is always greater than in the case of the triode. Thus the smaller beam width is obtained at the direct expense of a larger spot size which is one of the disadvantages of the tetrode type of gun.

Advantages of the Tetrode

In the first place let us consider some of the main features of the triode type of gun. The electrons leave the cathode and pass through a crossover and then diverge at an appreciable angle from the crossover. In the case of the triode this angle is rather large, and therefore the beam is likely to be fairly wide in the region of the focusing coil and also fairly wide in the region of the deflecting coils.

In order to keep the beam width as small as possible there is a tendency to design the triode in such a manner that the cut-off is high (long grid base) and this means, in turn, that the peak cathode loading (mA/cm²) will also be high. If the diameter of the grid aperture is kept constant at d_m then the peak cathode loading varies with cut-off V_c in accordance with the following relationship.

$$I_c = k_1 V_c^{6/7} \quad \ldots\ldots\ldots\ldots (2)$$

therefore we can say that the peak cathode loading is virtually proportional to the cut-off.

It is also desirable to keep the diameter of the grid aperture very small because the beam angle 2α is related to d_m by the following expression[2]:

$$\sin\alpha = \frac{0{\cdot}27 V_d\, d_m}{a^{3/4} V_c} \quad \ldots\ldots\ldots\ldots (3)$$

In this equation a represents the anode-grid distance and V_d the drive.

This can also be written as:

$$\sin\alpha = \frac{0{\cdot}27\, d_m}{a^{3/4} V_c^{3/7}} \cdot (I_b^2/9)^{1/7} \quad \ldots\ldots\ldots\ldots (4)$$

where I_b is the beam current.

The cathode loading will again be increased as d_m is reduced. It can be taken that anything that reduces the semi-angle α will also increase the cathode loading. If the beam angle is reduced by designing the tube so that it has a long cut-off then the modulation characteristic will be somewhat "degenerate" (i.e. poor slope). On the other hand, if the beam angle is reduced by designing the tube so that the grid aperture (d_m) is very small then the associated grid-cathode distance c will also have to be very small and this means that the assembly is difficult to construct. The final grid to cathode distance which appears after the tube has settled down in operation is likely to be slightly different to that which was given to the electron gun while it was on the assembly bench.

The cathode coating usually shrinks and its thickness is reduced by approximately 20 per cent during activation and the cathode tube would probably expand during heating. Also, the surface of the modulator might move slightly towards or away from the cathode.

These effects would be troublesome if attempts were to be made to design cathode-ray electron gun assemblies which have a very small value of c.

Modulator Cut-Off

According to the formula given by Moss[3] the cut-off for the triode type of gun is given by the formula (final anode voltage V_2 assumed to be constant).

$$V_c = K_2 d_m^3/bca \quad \ldots\ldots\ldots\ldots (5)$$

where the symbols have the significance as already defined and b represents the thickness of the modulator material. If the final anode voltage V_2 is variable then the cut-off varies linearly with the final anode voltage V_2.

That is:

$$V_c = K_3 V_2 \quad \ldots\ldots\ldots\ldots (6)$$

In the case of the tetrode, however, we have another electrode, known as the first anode, situated between the modulator and A_2 and the field from A_2 makes only a a very small contribution to the resultant field at the surface of the cathode. The potential gradient at the surface of the cathode is therefore determined almost entirely by the composite effect of the modulator and the first anode. The cut-off V_c of the tetrode tube is therefore determined by the potential on A_1 and almost independent of the potential on A_2. This is one of the most important advantages of the tetrode tube as compared with the triode because it means that one design of electron gun can be operated satisfactorily over a fairly wide range of values of final anode potential V_2. The cut-off voltage can be kept reasonably constant at any required value merely by suitable adjustment of the potential of the first anode. In practice there are limitations to this universal feature of the tetrode and it is not possible to design a tetrode which is equally efficient when it is operating at values of V_2 which differ very widely from that for which it was originally designed.

Spot Size

The triode type of gun always gives a smaller fluorescent spot when viewed in the head-on direction and this is due

to the following factors:

(1) The grid diameter is usually small, this leads to a small size of crossover as explained later on.

(2) The magnification ratio is less than that of the tetrode. The reason for this is that the tetrode has been designed so that it can accept a beam of a certain angle of divergence from the crossover and will then deliver a beam which has a smaller angle of convergence to the spot on the screen than would have been delivered under similar circumstances by a triode type of gun. The smaller magnification ratio of the triode leads directly, of course, to a smaller final spot on the fluorescent screen.

(3) The ratio of drive to cut-off (that is V_d/V_c) is usually less for the triode than in the case of the tetrode. The fraction V_d/V_c determines the area of the emitting surface of the cathode which is called into action and if this is small the crossover size will tend to be small. The size of the crossover will be small because of the smaller degree of spherical aberration and also, more directly, because the crossover size depends to some extent on the ratio V_d/V_c.

(4) The semi-angle of convergence θ_s into the spot on the screen is greater in the case of the triode and this also leads to a smaller spot in accordance with the Langmuir relationship[4],

$$\sigma_s = \sigma_c[(V_s'e/kT) + 1]\sin^2\theta_s \quad \ldots\ldots\ldots \quad (7)$$

where σ_s = maximum current density at the screen

σ_c = maximum current density at the crossover

V_s' = final voltage at the screen

k = Boltzmann's constant

θ_s = semi-angle of convergence into the spot at the screen

T = cathode temperature in °K

This formula is quite independent of space charge considerations. It is merely the electron optical expression of normal relationships in ordinary geometrical optics and it is the consequence of the application of the following formula taken from ordinary light optics,

$$y_o/y_i = n_i u/n_o v \quad \ldots\ldots\ldots\ldots\ldots \quad (8)$$

$$B_o/B_i = (n_o/n_i)^2 \quad \ldots\ldots\ldots\ldots\ldots \quad (9)$$

where y_o = size of object

y_i = size of image

n_o = refractive index in object space

n_i = refractive index in image space

u = distance of object from lens

v = distance of image from lens

and

B_o = brightness of object

B_i = brightness of image.

The Langmuir relationship is really another form of expression of the magnification principle as outlined by formula (1).

The requirements that θ_s should be small are often suggested as a desirable feature in connexion with any kind of electron gun and would appear, at first sight, to be in confliction with the Langmuir relationship. In a sense there is a confliction of condition because θ_s is required to be small only because of spherical aberration in the focusing lens and difficulties in providing a deflecting field which will handle a beam of large diameter in the scan coils.

Summary

For the reasons given above it will be evident that the triode always gives a smaller spot size, and therefore better resolution, at the centre of the screen than the tetrode, but the greater width of the beam in the triode tends to give rise to deflexion defocusing trouble much more readily than in the case of the tetrode.

The size of the crossover varies inversely as the potential at the point in space where the crossover has been formed. It has been suggested that the potential at the crossover is greater in the case of the tetrode than in the case of the triode. There does not appear to be any evidence to indicate that the potential at the crossover is statistically any different in the tetrode as compared with the triode. The spot size of the triode is smaller than that of the tetrode because the magnification ratio is less than that of the tetrode.

If one considers the range of normal values of peak beam current as used in direct viewing television tubes, the greater beam width of the triode does not give rise to a confusion of spot size in the central region of the screen especially when a solenoid type of focusing lens is used, because in nearly every case, the solenoid is capable of dealing with the greater beam width of the triode just as easily as that of the smaller beam width of the tetrode.

If, however, the focusing is carried out by means of a permanent magnet type of lens, the beam angle is of considerably greater importance because permanent magnet lenses cannot deal with wide electron beams as well as the solenoid type of lens.

In one particular experiment it was found that the solenoid could hold focus on both triode and tetrode tubes as the drive was increased from cut-off point at 60V until the total drive was 50V in each case. Thus each tube had a cut-off value of 60V and could be driven within 10V of zero bias before the spot size became too confused for television reception (at a degree of resolution of 2·5Mc/s).

When permanent magnet focusing was used instead of the solenoid the results were very much different. In this case, the tetrode could still be given a drive of 50V whereas the triode could only be driven to the extent of 30V before the spot (as viewed in the head-on direction) became too confused to be capable of giving a television picture at the reasonable degree of resolution of 2·5Mc/s. It should be emphasized that the tests just described are concerned only with spherical aberration of solenoid and permanent magnet focusing systems on tetrode and triode tubes in the undeflected head on direction only. Defocusing due to deflexion will be considered in the next paragraph.

Deflexion Defocusing

If the degree of focus of the spot deteriorates as the spot is deflected towards the edge of the screen, the spot is said to be suffering from deflexion defocusing.

The principal causes of deflexion defocusing are:—

(1) Non-uniform transverse field in the region of the scan coils. If the electron beam was very narrow this would give rise to distortion of the pattern (pin cushion effect or barrel distortion) but not deflexion defocusing. If the beam has appreciable width then this non-uniform field can cause different sections of the beam to be deflected to different degrees and so give rise to deflexion defocusing.

(2) Axial component of field in the scan coils.

This can contribute to deflexion defocusing of the beam to a certain extent, but this is not likely to be of any great importance with well designed scan coils.

(3) Interaction between the scanning field and the focusing field.

In certain cases the field from the scan coils can penetrate into the region of the focusing solenoid (or permanent magnet) and give rise to a variation of focus of the beam. This error in focusing condition will be a maximum when the field from the scan coils is a maximum and therefore the beam will appear to be suffering from deflexion defocusing.

(4) Beam too wide in region of the scan coils.

This is by far the most frequent cause of deflexion defocusing. The smaller angle of the beam from the tetrode makes deflexion defocusing much easier to avoid. The beam width might be due to poor design of the gun or wrong position of the focusing coil or low emission.

(5) Spherical aberration.

This is not in itself a cause of deflexion defocusing, but if the spot is confused owing to spherical aberration as viewed at the centre of the screen it will tend to become still more confused when deflected. In this way a badly focused spot owing to spherical aberration will appear to be giving rise also to deflexion defocusing.

(6) Scattering on electrode system.

This type of deflexion defocusing occurs only on electrostatically focused guns. It comes about when a beam of large dimensions is passing too close to some portion of the electrode system and is being scattered in an undesirable manner. If this takes place it is very probable that secondary electrons might also be emitted which would give rise to a diffuse tail to the spot. This effect will reveal itself as a function of the deflecting field because the beam in the head-on direction is probably just missing the obstruction but impinges on it during the period of maximum deflecting field intensity. This takes place because the field from the deflecting coils is capable of penetrating into certain portions of the electrode assembly.

The essential advantage of the tetrode is that the narrower beam makes deflexion defocusing easier to avoid. To some extent the apparently greater superiority of the tetrode with regard to deflexion defocusing is an optical delusion. The triode gives a finer spot in the central region of the screen and a rather more diffuse spot at the outer edges of the raster, as compared with the tetrode. This gives rise to the impression that the triode is much worse from the point of view of deflexion defocusing than it really is when considered on purely technical grounds. It is quite safe to say that the tetrode has earned a reputation for comparative freedom from deflexion defocusing to a large extent because it gives rise to a considerably larger spot at the centre of the screen in any case. Therefore the contrast between the spot size when deflected as compared with that at the centre is not as marked as in the case of the triode.

All the above remarks must be taken to apply to the average typical designs of commercial types of triode and tetrode tubes. It could be said that it is possible to reduce the grid aperture of the tetrode and so reduce the crossover size and therefore improve the focal spot as seen in the undeflected direction. This would increase the cathode loading and thus remove one of the main advantages of the tetrode type of gun.

Crossover Size

In earlier papers[5] on cathode-ray tube design it has been said that the size of the crossover is very largely dependent on the following factors:—

(1) The size of the crossover is inversely proportional to the square root of V_c' where V_c' is the potential at the crossover.

(2) The size of the crossover varies directly as $a^{3/2}$ where a is the anode-modulator distance.

(3) The size of the crossover is directly proportional to $\sqrt{E_o}$ where E_o is the energy of emission of the electrons from the cathode in volts.

Several other factors might have an influence on the size of the crossover. The more important of these secondary factors are:—

(4) Spherical aberration in the crossover-forming lens.

(5) Space charge effects near the cathode.

(6) Diameter of the grid aperture.

(7) Modulator potential.

It is possible that space charge could modify the A_1A_2 lens and therefore have some effect upon the size of the crossover. It is difficult to obtain any direct evidence as to what extent this takes place, but it would appear that any material disturbance of the field set up by the crossover-forming lens because of the electron space charge is negligible in the case of electron beams of the intensity used in a normal cathode-ray tube.

It is sometimes said that the superior performance of the tetrode is due to the fact that the high field gradient at the crossover reduces the space charge and therefore the crossover is more sharply defined. There does not appear to be any evidence to support such a claim because the spot size is always greater in the case of the tetrode as compared with the triode. The increase of spot size does not imply that the crossover size is greater in the case of the tetrode, because the greater spot size comes about by virtue of the fact that the magnification ratio is greater in the tetrode. The spot size appears to be increased by the amount that would have been expected if the crossover size were to have remained substantially the same in each case. It appears therefore, that for all normal purposes the crossover size in the case of the tetrode and the triode can be considered to be the same.

CROSSOVER SIZE AS A FUNCTION OF MODULATOR DRIVE

It is usually said that the size of the crossover is independent of the drive if space charge and aberrations are neglected.

The formula which determines the position of any point on the crossover (in a radial direction) corresponding to any point of emission from the cathode is given by[8]:

$$y_c = y_o \sqrt{\left(\frac{E_o}{E_o + V_c'}\right)} \cdot \frac{\sin \theta_o}{\sin \theta_c} \quad \ldots\ldots\ldots (10)$$

y_c = the point on the crossover.

y_o = the corresponding point on the cathode.

E_o = energy of emission of the electrons from the cathode in volts.

V_c' = potential at the crossover in volts.

θ_c = semi-angle of convergence to the point on the crossover.

θ_o = angle of emission of electrons of energy E_o to the normal to the cathode surface.

Now as the drive V_d is increased y_o will increase and it can be shown[6] that formula (10) leads to:

$$y_c = K_4/\sqrt{V_2} \cdot (I_b/i_{cm})^{\frac{1}{2}} \quad \ldots\ldots\ldots \quad (11)$$

where K_4 is a constant

I_b total beam current

i_{cm} mean cathode loading

V_2 final anode potential.

The formula (11) can be derived from (10) provided that the variation of θ_c with drive is given full consideration.

If, to a first approximation it were to be assumed that θ_c remains small as the drive is increased, then it would be found that y_c is independent of drive and this would lead to the erroneous conclusion that the crossover size remains constant as the drive is increased.

Crossover Size as a Function of Anode Potential

Equation (10) indicates that y_c varies as $K_5/\sqrt{V_2}$, where V_2 is the final anode potential and K_5 is a constant. This follows directly from equation (10) if it is assumed that the potential at the crossover V_c' is proportional to the final anode potential V_2 and it is almost certain that such a relationship should exist.

This formula also indicates that the limit of the crossover radius for electrons of any one energy value E_o is formed by taking $\theta_o = 90$ and this gives the expression:

$$y_c = y_o\sqrt{\left(\frac{E_o}{E_o + V_c'}\right)} \cdot \frac{1}{\sin\theta_c} \quad \ldots\ldots\ldots \quad (12)$$

as representing the extreme radius of the crossover for electrons of energy of emission corresponding to E_o. This indicates that y_c is proportional to $\sqrt{E_o}$ and if E_o were zero, the crossover would be represented by a single point on the axis of beam.

Crossover Size as a Function of the Grid Diameter

Consideration of the expression (10) for y_c leads to the conclusion that the cross over diameter will increase if the diameter of the grid aperture d_m is increased. This means that if we take two tubes which have the same cut-off and if we drive them to the same extent then we shall find the crossover size is greater in the case of the tube with the large value of grid aperture d_m.

Movement of Crossover

As the drive increases the position of the crossover moves away from the cathode towards the final anode. The actual size of the crossover is usually considered to be approximately one-tenth of the diameter of the actual emitting surface of the cathode. The crossover may be situated anywhere between the modulator and the first anode, but it is customary to assume that the crossover can be considered to be situated midway between the modulator and the first anode.

Variation of Focusing Power with Final Anode Voltage

It is often said that one of the advantages of the tetrode is the fact that the spot does not go out of focus so readily when the final anode potential is changed by a small amount from its normal value. Actual measurements indi ate that the power of the focusing lens varies with the final anode voltage in the same way and to the same extent in the case of the tetrode, as in the case of the triode.

Nevertheless, in spite of the academic observations as indicated above, it is certainly true in practice that the final anode voltage can be varied to a greater extent in the case of the tetrode before the spot appears to be off focus to a certain degree. This comes about because the beam is converging more slowly in the tetrode and therefore the depth of focus is appreciably greater than in the triode.

If the final anode voltage V_2 is increased while V_1 is kept constant it might be expected that the power of the A_1A_2 lens would have been increased and therefore the necessary increase in power of the final focusing lens would be less than in the case of the triode. Measurements indicate that there is no appreciable difference in this respect in the case of the particular tetrode tubes which were examined and therefore the A_1A_2 lens does not increase in power very much as the V_2 voltage is varied (over a range of about 2kV from its normal operating value).

In certain cases it has been observed that the power of the final focusing lens has to be increased to an even greater value in the case of the tetrode than in the case of the triode for a given change in V_2. This implies that the power of the A_1A_2 lens has actually decreased as V_2 was increased. This is possible if the A_1A_2 lens consists of a very short disk-shaped diaphragm on the A_1 side of the combination. In such cases the tetrode is even more liable to pass out of focus as the V_2 voltage is varied than the triode.

However, because these various factors compensate one another to a considerable extent the final result is that the tetrode and triode show the same variation of final lens focusing power as V_2 is varied, but the tetrode appears to hold focus better than the triode because the beam is more nearly a line beam than the triode, and therefore the depth of focus is considerably greater than that of the triode.

Power of the Final Focusing Lens

The actual power required in the final focusing lens is, of course, always slightly less for the tetrode than for the triode because of the slight prefocusing action of the A_1A_2 lens.

Cathode Loading

According to Moss[38] peak cathode loading is given by:

$$i_{cp} = \frac{0{\cdot}0145\,V_d^{3/2}}{d_m^2} \quad \ldots\ldots\ldots\ldots \quad (13)$$

and the radius of the portion of the cathode which is emitting at a time when the drive is represented by V_d is given by:

$$r_o = (V_d/V_c) \cdot (d_m/2) \quad \ldots\ldots\ldots\ldots \quad (14)$$

These formulæ hold good for both triode and tetrode.

Now the formula for the beam angle is:

$$\sin\alpha = \frac{0{\cdot}27\,V_d d_m}{a^{3/4}V_c}$$

(where α is the semi-angle of the beam from crossover) and we have seen that the essential feature of the tetrode is that α can be larger than when a triode type of gun is used.

This means that d_m can be larger than in the case of the triode, also the ratio of V_d/V_c can be greater.

Now let us consider the case where d_m is constant but V_c is variable.

The beam current is represented by $I_b = (3V_d^{7/2}/V_c^2)$

and therefore if I_b is constant we have the relation $V_d^{7/2} = K_4 V_c^2$, where K_4 is a constant.

This means that (for constant beam current I_b) the drive V_d will be proportional to $V_c^{4/7}$, that means:

$$V_d = K_5 V_c^{4/7} \text{ for constant } I_b \quad \ldots\ldots\ldots (15)$$

Now the mean cathode loading is given by:

$$i_{cm} = \frac{12 V_d^{3/2}}{\pi d_m^2} \quad \ldots\ldots\ldots\ldots\ldots (16)$$

and therefore if d_m is kept constant and I_b is constant, but V_c is varied:

$$i_{cm} = K_6 V_c^{6/7} \quad \ldots\ldots\ldots\ldots\ldots (17)$$

Therefore the mean loading (at constant I_b and constant d_m) is nearly proportional to the cut-off V_c.

Now V_c can be smaller for the tetrode than for the triode because the larger beam angle which then appears in the case of the tetrode is immediately reduced by the action of the A_1A_2 converging lens. Thus one of the fundamental advantages of the tetrode is that the mean cathode loading can be lower than that of the triode because the tube can be designed so that it has a lower value of cut-off. In addition, the tetrode can be designed so that it has a larger modulator aperture (because the corresponding larger beam angle from the crossover can be dealt with by the action of the A_1A_2 lens), and this leads again directly to a lower value of peak and mean cathode loading.

When I_b and d_m are kept constant and V_c is varied, it has been shown that the mean cathode loading is approximately directly proportional to the first power of V_c which is a very simple relationship and this applies equally to the tetrode or triode type of gun. Therefore, the long values of cut-off which we tend to adopt on the triode type of gun leads very directly to high values of cathode loading and should be avoided if possible.

The usual figures for the peak cathode loading which are attained in the design for cathode-ray tubes which have oxide coated cathodes are between 250 and 500mA/cm^2. If Lemmens cathodes or sintered nickel cathodes can be developed for this purpose it is considered possible that cathode-ray tubes could be designed so that much higher values of cathode loading would be possible[7]. This would mean that for a given beam current the size of the spot as observed on the fluorescent screen could be reduced considerably as indicated by the Langmuir relationship. Also, the Langmuir relationship indicates that a great improvement could be brought about if the cathode could be designed in such a manner that it could deliver this greater emission at a lower temperature.

Modulation Characteristics

Various formula have been given for the beam current of a cathode-ray tube as a function of the various relevant parameters. Thus Allard[7] gives:

$$I_b = 3V_d^3/V_c^{3/2} \quad \ldots\ldots\ldots\ldots (18)$$

whereas Moss[3] gives:

$$I_b = 3V_d^{7/2}/V_c^2 \quad \ldots\ldots\ldots\ldots (19)$$

These expressions do not differ in practice to any great extent and they apply to both tetrode and triode type of gun assemblies. It has been said that one advantage of the tetrode over the triode is that is has a steeper modulation characteristic than the triode.

If we have a tetrode tube and a triode tube with the same value of cut-off V_c then the modulation characteristic would be substantially the same for each tube.

In order to obtain a small beam angle in the case of the triode it is usual to design a tube which has a long cut-off (approximately 60V) and this fact gives rise to a modulation characteristic which is less steep than the tetrode. The corresponding tetrode type of tube could be designed so that the cut-off is no greater than 35V in order to obtain appreciably the same width of electron beam in the region of the scan coils.

The above formulæ for the modulation characteristic would imply, in each case, that I_b is dependent only on V_d and V_c. In practice it is found that when the distance between the modulator and cathode is small the modulation characteristic tends to have a steeper slope than would be given by these formulæ (18) or (19).

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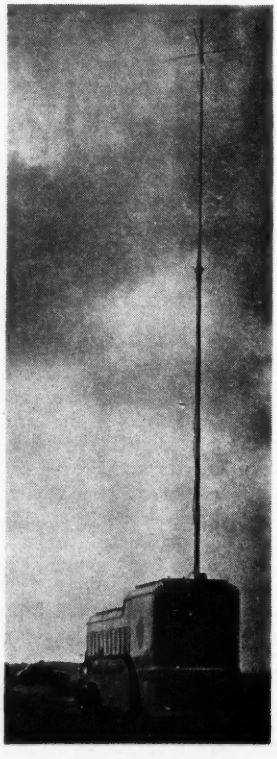
Automobile Association Mobile Office

Illustrated is the latest addition to the Automobile Association fleet. It is a super mobile office designed and constructed by British Films Ltd, of Balham, London, on a Carrimore articulated semi trailer with a Seddon Tractor Unit as the prime mover.

The body is divided into four main sections, the wireless control room, in which Pye Telecommunications equipment is installed, is situated in the forward section and separated from the office and reception area by a partition with sliding glass panels through which operation may be seen while no inconvenience to members is caused when messages are sent or received.



G.P.O. lines may be connected to the office which is wired for two phones, one at the counter and the other for members' use in an acoustically treated booth.

The upper rear section is fitted out as a living compartment for a crew of two.

The space beneath the soundproof floor of the living compartment houses the generator and provides a capacious stowage compartment.

A feature of the unit is a hydraulic telescopic mast, which is built into the rear of the body and to which the aerial is attached. The mast is electrically operated and can be extended to a height of 60 feet in approximately four minutes by simply pressing a button. Jacks are fitted to the trailer to stabilize the body when the mast is extended.

Some High Impedance Current Generating Circuits

By J. H. McGuire*, B.Sc., A.M.I.E.E., A.Inst.P.

A basic high impedance current generating circuit is described together with practical designs developed from it.

IT is often necessary, as in the stabilization of electromagnetic lens systems and in the use of analogue computers, to apply to a network a current which is independent of the network impedance. One way of doing this is to apply to the load, through a very high resistance, a voltage waveform having the same time characteristic as the required current waveform. This is obviously inefficient and is often very inconvenient as it necessitates the generation of an e.m.f. many times the potential difference developed across the load.

This note describes the basic and practical designs of a circuit which will generate current waveforms with a reasonable efficiency.

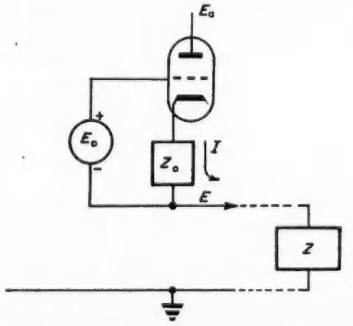


Fig. 1. A simple potentiometric current generating circuit

Two Simple Current Generating Circuits

Fig. 1 illustrates the simple high impedance current generating circuit which forms the basis of the various circuits described in this note. Its performance is analysed in Appendix 1, where it is shown that the arrangement of Fig. 2 is an equivalent circuit. If Z_o is resistive the circuit waveform will be substantially that of the applied voltage waveform, though it may be noted that this may be modified somewhat if Z_o is complex.

In cases where the output capacitance of the circuit must be low and the source E_o is capable of supplying the output current I, the alternative circuit illustrated in Fig. 3 may be used. The generator E_o will almost certainly constitute the largest stray capacitance to earth in either arrangement. In Fig. 1 this stray capacitance will be connected directly across the output and can only be charged through the impedance Z_o. In the circuit of Fig. 3, however, the stray capacitance of the generator E_o will be shunted by the output impedance of the cathode-follower.

The performance of the circuit is substantially that of Fig. 1 and Appendix 1 is applicable provided that the factor μE_o be replaced by $(\mu + 1)E_o$ wherever it appears.

Where greater stability of current is required, improved circuits may be developed from those of Figs. 1 and 3 by arranging for the potential drop across the valve to be maintained constant.

* *Fire Research Station, D.S.I.R.*

Pentode Current Generating Circuits

The circuits of Figs. 4(a) and 4(b) illustrate the use, as a current generator, of a pentode, the screen grid of which is maintained at a constant potential with respect to the cathode. The output current, in both circuits, will be independent of the output voltage to the extent that the valve behaves as an ideal pentode, i.e. to the extent that anode current is independent of anode voltage.

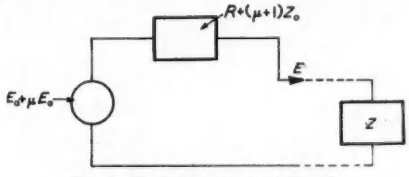


Fig. 2. Equivalent circuit of Fig. 1

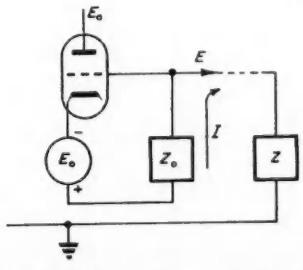


Fig. 3. An alternative current generating circuit

This type of circuit is of most practical value in generating a constant current and in this case E_o is constant, Z_o being a pure resistance. One floating supply may then serve for both E_o and V_B if a circuit of the type shown in Fig. 4(a) is to be used. Such an arrangement is illustrated in Fig. 4(c).

Two and Three Valve Current Generating Circuits

Fig. 5 illustrates a circuit which is substantially of the same design as that of Fig. 1, but which has a series valve in the h.t. line, so that the potential difference across the cathode-follower is maintained nearly constant. Since there is no current drain from the voltage source E_B a battery may be used as illustrated in the diagram.

It is shown in Appendix 2 that the arrangement of Fig. 6 is an equivalent circuit and that, in most practical cases, the variation of output current with output voltage is μ times less than with the circuit of Fig. 1, μ being the amplification factor of either valve.

If the output capacitance of the circuit must be low and the source E_o is capable of supplying the output current I, the alternative arrangement of E_o and Z_o, described previously, may again be used. The performance will be substantially unaltered.

With either arrangement it might also be convenient to

connect the lower end of the potential source E_B to the lower end of Z_o and not to the valve cathode.

Where it is undesirable to include any batteries in the circuit a stability approaching the order of the above may be obtained by incorporating a third valve and neon stabilizer tubes. Such a circuit, operating on the same principle as the circuit of Fig. 5, is illustrated in Fig. 7. A similar circuit based on the alternative arrangement of E_o and Z_o would be cumbersome as it would require a negative supply line in addition to the positive h.t. supply.

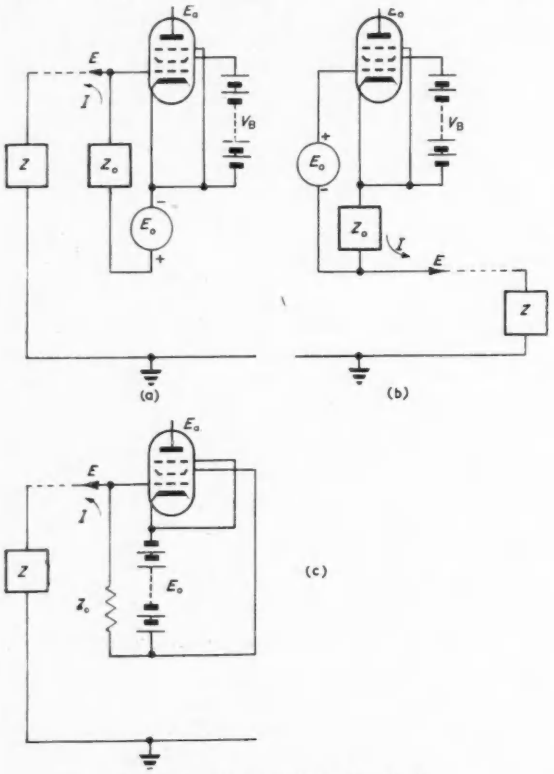


Fig. 4. Pentode current generating circuits

Currents of Opposite Polarity

If currents of the opposite polarity are required, the load Z in the circuits of Figs. 1 to 5 may be placed in series with the h.t. supply. With this arrangement the positive side of the h.t. supply would be earthed, and thus the lower end of the generator E_o would be at a fixed potential with reference to earth. The capacitance of the generator E_o would therefore become unimportant and it would be pointless to use a modified arrangement of the circuit of Fig. 3.

The circuit of Fig. 5 would be simplified if the lower end of the potential source E_B were connected to the lower end of Z_o. The potential could then be derived from a potential divider across the h.t. line and in these circumstances the circuit of Fig. 7 would be redundant.

Conclusions

Several current generating circuits have been described and it is shown that in a practical example the output current waveform will be constant, with variations in output voltage, to within 4½ per cent for the simple circuit and ¼ per cent for the more complex circuits. Equivalent circuits are given and it is shown that, if a valve with an amplification factor of 20 is used, the simple circuit operating from supplies not exceeding 500V will give the same performance (within limits) as a circuit including a high impedance generator of e.m.f. 4·5kV. In the case of the more complex circuit, operating from supplies not exceeding 700V the e.m.f. of the equivalent high impedance

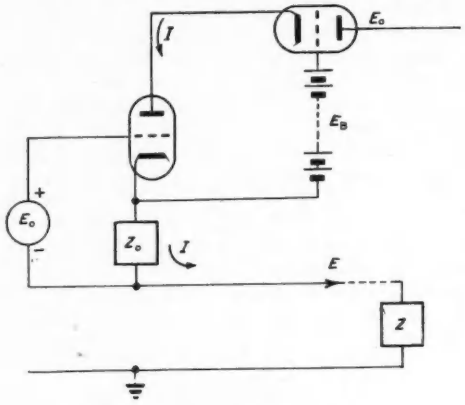


Fig. 5. An Improved Current Generator

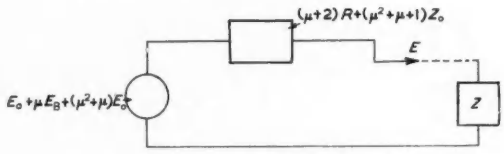


Fig. 6. Equivalent circuit of Fig. 5

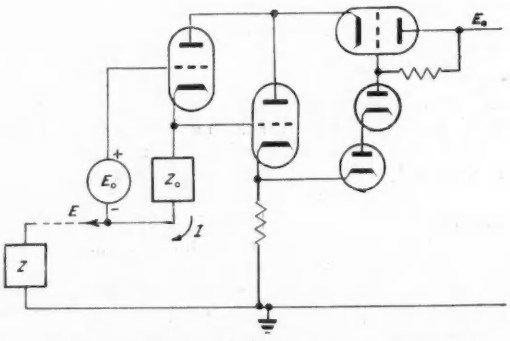


Fig. 7. A neon tube stabilized current generating circuit

generator would be of the order of 88kV, again assuming that valves with an amplification factor of 20 are used.

The circuits of Figs. 4(c) and 3 have been used successfully to give constant and impulsive currents respectively in an electric analogue of heat conduction.

Acknowledgment

The work described in this article forms part of the programme of the Joint Fire Research Organization of the Department of Scientific and Industrial Research and Fire Offices' Committee; the article is published by permission of the Director of Fire Research.

Acknowledgment is due to Mr. D. I. Lawson for drawing attention to the circuit arrangement shown in Fig. 1.

Appendix 1

A Simple Current Generator

If, in the circuit of Fig. 1, the valve is considered to be ideal and stray capacitances are neglected, then the current flowing through the load Z is given by:

$$I = \frac{E_a + \mu E_o}{R + (\mu + 1)Z_o + Z} \quad \ldots\ldots\ldots (1)$$

where μ and R are the amplification factor and equivalent d.c. resistance of the valve respectively.

Thus, provided the potential drop E across the load Z does not rise to such a level that the potential difference across the valve tends to zero, the circuit will behave as if it were the generator of an e.m.f. $(E_a + \mu E_o)$ with an internal impedance $R + (\mu + 1)Z_o$ (see Fig. 2).

The fractional variation of I with Z will be small provided Z is small compared with $R + (\mu + 1)Z_o$ and in these circumstances is given by:

$$\frac{dI/dZ}{I} \simeq \frac{-1}{R + (\mu + 1)Z_o} \quad \ldots\ldots\ldots (2)$$

In many applications of the circuit the load Z will be complex and it may not be practicable to evaluate equation (2). The performance of such circuits is best described in terms of the potential drop E across the load Z rather than in terms of Z. It follows from the equivalent circuit of Fig. 2 that provided E is small compared with $E_a + \mu E_o$, the fractional variation of I with E is:

$$\frac{dt/dE}{I} \simeq \frac{-1}{E_a + \mu E_o} \quad \ldots\ldots\ldots (3)$$

Thus if a valve with a μ of 20 is used in a circuit with an h.t. of 500V and E_o has a constant value of 200V, then a typical value of the maximum excursion of E will be 200V. On substituting these values in equation (3) it will be seen that the fractional difference between the current when the potential difference across the load varies between 0 and 200V is:

$$(\delta I/I)_{max} \simeq 4\tfrac{1}{2} \text{ per cent}$$

In the equivalent circuit of Fig. 2 the same potential difference E would be developed across the load if the generator developed an e.m.f. of 4·5kV and had an internal impedance of $R + (\mu + 1)Z_o$.

Appendix 2

An Improved Current Generator

If in the circuit of Fig. 5, the valves are considered to be ideal and stray capacitances are neglected, then the current flowing through the load Z is given by:

$$I = \frac{E_a + \mu E_B + \mu(\mu + 1)E_o}{(\mu + 2)R + (\mu^2 + \mu + 1)Z_o + Z} \quad \ldots\ldots (4)$$

where μ and R are the amplification factor and equivalent d.c. resistance of the valves respectively.

Thus, provided the potential drop E across the load Z does not rise to such a level that the potential difference across the valve tends to zero, the circuit will behave as if it were the generator of an e.m.f. $[E_a + \mu E_B + \mu(\mu + 1)E_o]$ with an internal impedance $[(\mu + 2)R + (\mu^2 + \mu + 1)Z_o]$ see Fig. 6.

The variation of I with Z will be small provided Z is small compared with $[(\mu + 2)R + (\mu^2 + \mu + 1)Z_o]$ and in these circumstances is given by:

$$\frac{dI/dZ}{I} \simeq \frac{-1}{(\mu + 2)R + (\mu^2 + \mu + 1)Z_o} \quad \ldots (5)$$

As with the previous circuit, many applications will involve complex loads and in these cases the performance is best described in terms of E, as follows:

$$\frac{dI/dE}{I} \simeq \frac{-1}{E_a + \mu E_B + \mu(\mu + 1)E_o} \quad \ldots\ldots (6)$$

The order of variation likely to be encountered in practice may be found by substituting appropriate values in equation (6). Thus, if $\mu = 20$, $E_a = 700$V and $E_B = E_o = 200$V then for a change in E of 200V $(dI/I)_{max} = 0{\cdot}23$ per cent.

In the equivalent circuit of Fig. 6 the same potential difference would be developed across the load if the generator developed an e.m.f. of 88·7kV and had an internal impedance of $(\mu + 2)R + (\mu^2 + \mu + 1)Z_o$.

New Equipment for Testing Television Valves

The M.O. Valve Co Ltd has developed a new table specially for conditioning and testing Osram N339 and U329 valves. Both types are used in domestic television receivers, the N339 as a line output-valve and the U329 as a booster diode with exceptionally high heater-cathode insulation. The new table subjects them to the same high peak voltages and currents as they encounter in service, and ensures a uniform high standard of performance.

Each table incorporates twelve test positions which will accommodate either type of valve. The valves are inserted and a Perspex window is drawn down over them. The peak voltages developed on the valves can then be increased from zero to maximum either manually or automatically to a preset sequence. Each valve is monitored by pressing the button located immediately below it, the peak output voltage being indicated on a meter let into the front of the table.

The test circuit for each valve is very similar to the line time-base circuit used in television receivers. The line transformer is loaded with a dummy coil to simulate the effect of the deflexion coils. All twelve test positions are driven by a negative 10kc/s pulse at the grid of the N339 from a common driver unit, the output of which is kept at a constant amplitude.

The peak voltage developed on the anode of the N339 is dependent on the rate of change of current through the valve at cut-off. The current flowing through the valve is controlled by a variable screen grid supply which, therefore, controls the peak voltage output.

The automatic conditioning is achieved by providing a stepped input voltage to the screen grid power supply from a thyratron operated timer unit. The number of switched steps available is 24 and the duration of each step is variable over a considerable range by adjustment of the thyratron circuit. The maximum screen grid voltage may be preset by a control on the front of the desk.

After the conditioning process is completed the equipment may be set up for testing the valves. The valves are switched on cold and the peak voltages are allowed to build up quickly to the maximum rating. This is the treatment the valves receive in a television receiver and the conditioning process ensures that no flashing will take place during testing and use.

Reliable Power Pack Design

By A. F. Standing*

A method is described which reduces the design of capacitor input power packs to simple calculations aided by graphs. Full details of the voltages and currents both a.c. and d.c. throughout the power pack can be readily calculated, enabling correct components and ratings to be chosen.

IN many applications of electronic equipment reliability is of the utmost importance, and a great deal of work is going on to increase reliability, including the study of design methods that enable components to work within their ratings at all times.

The following method reduces the design of capacitor input power packs to simple calculations aided by graphs. Full details of the voltages and currents both a.c. and d.c. throughout the power pack can be readily calculated, enabling correct components and ratings to be chosen.

A rectifier has five main ratings (a) peak inverse voltage, (b) mean anode current, (c) peak anode current, (d) surge anode current, (e) heater cathode voltage. For any given load or mean anode current, a minimum applied voltage is required before the rated peak anode current is reached. If this minimum voltage is below the value set by the rated peak inverse voltage, the design is limited by the rated peak anode current; if, however, this minimum voltage is above the peak inverse voltage, then the design is limited by the rated peak inverse voltage. A list of valves and their limiting ratings under full load conditions is given in Table 1. As the load current and/or the applied voltage is reduced, the maximum peak anode current is reduced and the valve works well within its ratings. Two methods of design are given to cover the two cases, peak current limited and peak inverse limited, and the calculation of their regulation curves.

TABLE 1

VALVE	I_L' (mA)	I_V'' (mA)	P.I.V. (kV)	LIMITING RATING
CV140 (6AL5)	9	54	0.414	I''_V
CV493 (6X4)	68	207	1.238	I''_V
CV378	225	1.125	1.125	P.I.V.
5Z4G	126	374	1.260	I''_V
5U4G	203	608	1.400	I''_V
CV261	4.5	36	11.25	I''_V

Theory

(a) Design Limited by Peak Anode Current

If the power pack is in a stable condition, i.e. the load and d.c. voltage remain constant, the charge lost in feeding the load is replaced during the rectifier conduction time.

Since charge is the product of current and time:

$$I_L t_c = I_v' t$$

where I_L = load current

I_v' = mean rectifier anode current during conduction period

t = rectifier conduction time

t_c = load discharge time.

Assuming charge and discharge to be linear, (these assumptions are discussed later) the voltage waveforms are as shown in Fig. 1.

The ratio of peak valve current I_v'' to mean valve current I_v' is equal to the ratio A of maximum height to mean height of the shaded area (see appendix). This ratio does

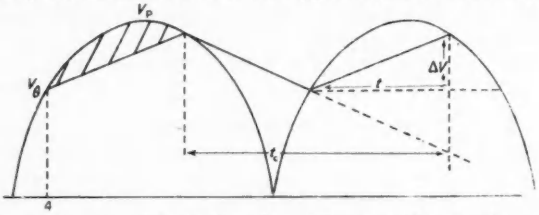


Fig. 1. Assumed ripple waveform for a full wave rectifier, superimposed on to the input voltage

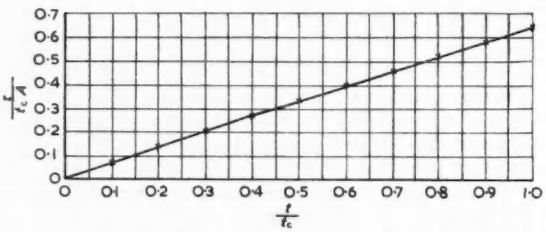


Fig. 2. Curve for calculating t/t_c in the peak anode current limited case

not change significantly with ΔV when ΔV is less than 20 per cent of V_p. When ΔV is greater than 20 per cent the accuracy falls off.

Now $A = I_v''/I_v'$ and $t/t_c = I_L/I_v'$

$$t/At_c = I_L/I_v'' \quad \ldots\ldots\ldots\ldots\ldots (1)$$

The ratio of conduction time to discharge time does not depend on the value of capacitor used, but on the ratio of load current to peak anode current during the conduction period.

Using equation (1) and the graph of t/At_c against t/t_c, Fig. 2 (see appendix), the value of t/t_c can be obtained.

The ripple voltage ΔV depends on the discharge time $t_c - t$, less the load current I_L and the capacitor C.

$$\Delta V = \frac{I_L (t_c - t)}{C} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

Assuming the mean value of the ripple voltage to be $\Delta V/2$ the direct voltage across the capacitor is:

$$V_{dc} = V_\theta + \Delta V/2 \quad \ldots\ldots\ldots\ldots\ldots (3)$$

For calculation of V_θ see Fig. 1 and appendix.

From appendix:

$$V_0 = V_p \sin\theta \quad \ldots\ldots\ldots\ldots\ldots (4)$$

where:

$$\theta = \cos^{-1}\left[\frac{\Delta V}{2V_p \sin ft\pi}\right] - ft\pi$$

* Radar Research Establishment, M.O.S.

This means that, to a first approximation, the output voltage does not depend on the value of capacitor used.

The maximum voltage V_a'' across the rectifier and series resistance is proportional to the maximum height of the shaded area, Fig. 1, and is given by (see appendix):

$$V_a'' = V_p\left[\sin\alpha - \sin\theta - \frac{(\alpha-\theta)\,\Delta V}{(\pi t/t_c)\,V_p}\right] \ldots\ldots (5)$$

where $\cos\alpha = \dfrac{\Delta V}{(\pi t/t_c)\,V_p}$

To limit the peak anode current to the required value, the total resistance R_T in the charging circuit must equal the ratio of maximum voltage V_a'' to peak valve current I_v'':

$$R_T = V_a''/I_v'' \ldots\ldots (6)$$

The resistance R_T is made up of four parts, transformer leakage inductance being neglected: (a) rectifier at I_v'', (b) resistance of transformer secondary, (c) primary transformer resistance reflected into the secondary, (d) external series resistance R_s. Curves of rectifiers resistance with load current are given in Fig. 3. The value of the series resistance R_s is given by:

$$R_s = R_T - R_v - R \ldots\ldots (7)$$

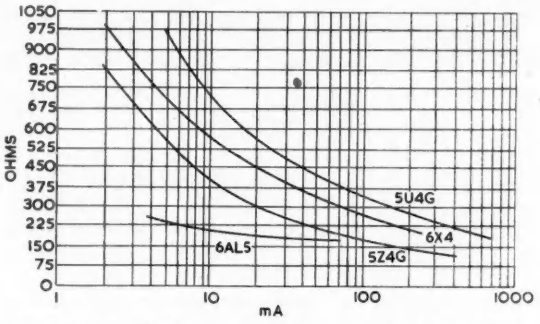


Fig. 3. Relationship between resistance and current for a number of rectifiers

where R_s = external series resistance

R_T = total required resistance

R_v = rectifier resistance at I_v''

R = total transformer resistance.

The dissipation of R_s is given by the mean valve current during the conduction time the value of R_s, and the charge and discharge ratio:

$$W_R = t/t_c\,(I_v')^2 R_s$$

but:

$$A = I_v''/I_v'$$

$$W_R = (t/t_c)\,R_s\,(I_v'')^2/(A)^2 \ldots\ldots (8)$$

From the above equations, a full load design can be produced provided the limiting rating is the peak anode current.

(b) Design Limited by Peak Inverse Voltage

When the design is limited by the rated peak inverse voltage, it means the required R_T from the previous method is less than the rectifier resistance at that peak anode current. It is therefore necessary to design the power pack from the known applied voltage, R_T and load current.

Now from equations (1) and (6):

$$t/t_c = A\,(I_L/I_v'')$$

and:

$$R_T = V_a''/I_v''$$

The ratio A of peak anode current to mean anode current is the same as the ratio of peak anode voltage to mean anode voltage (during conduction time).

Thus:

$$A = V_a''/V_a'$$

Combining equations:

$$t/t_c = I_L R_T/V_a'$$

Dividing through by V_p:

$$V_a'/V_p = (I_L R_T/V_p)\,.\,1/(t/t_c) \ldots\ldots (9)$$

Using equation (9) and the graph of t/t_c, Fig. 4 (see appendix), successive approximations will give the value of t/t_c to the accuracy required for any given value of applied voltage, load current and R_T. Having found the value of t/t_c, calculation will give V_{dc} and ΔV for the load used.

The design method for P.I.V. limited valves can be used to calculate the output voltage and ripple at any load (see discussion of assumptions), thus enabling the regulation of the power pack to be calculated irrespective of the original design method used. The regulation of change of output voltage with load of the power pack is not linear, requiring at least three points to define the regulation curve. Two points are available: (a) no load where the output voltage equals V_p, (b) full load calculated from the graphs and

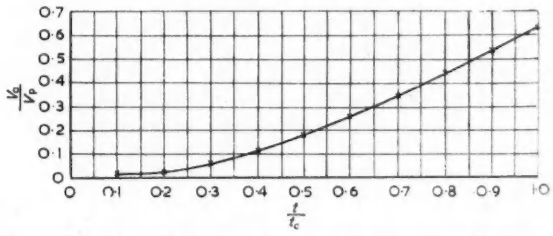


Fig. 4. Curve for calculating t/t_c in the peak anode voltage limited case

equations. It is therefore necessary to calculate the output voltages at loads other than full and no load. Normally calculations for half load will provide enough information to enable the regulation curve to be constructed.

The two methods can be applied to half and full wave circuits by using the appropriate values of t_c, $1/f$ and $1/2f$ respectively, where f is the supply frequency.

Voltage doublers of conventional type can be calculated on the basis of two half-wave rectifiers whose outputs add. Ripple frequency will be twice the supply frequency and the amplitude ΔV_T will be the sum of the two ripple voltages, one of which is 150° out of phase with the other giving a final ripple amplitude equal to the half-wave case.

Discussion of Assumptions

The theory is based on the following three assumptions:

(a) linear fall of voltage during discharge;

(b) linear rise of voltage during charge;

(c) A remains constant for all values of ΔV.

The error introduced by assuming linear discharge is very small, and can be neglected in comparison with the errors introduced by the other assumptions.

Since A is not constant for all values of ΔV (from geometry) the curve of t/At_c against I_L'/I_v'' is one of a

family of curves. The curve given represents this relationship with reasonable accuracy up to 20 per cent ripple, i.e. $\Delta V = 0{\cdot}2\,V_p$.

The limiting assumption is that of linear charge, this will predict in the ideal rectifier case (zero forward resistance $\propto I_v''$) an infinite charging current. In fact the charging current in this case is governed by the rate of rise of the applied voltage and is given by:

$$I = Cdv/dt$$

In practice reasonably accurate results are obtained for values of I_v''/I_L not exceeding 6·0.

Examples of Method

To illustrate the methods, a full wave 50c/s power pack using a CV493 (6X4) is designed.

The power pack is fed from a 250V input, 350-0-350V output, 50c/s transformer, and uses a CV493 full-wave rectifier feeding a 4μF capacitor (Fig. 5).

TRANSFORMER

Primary resistance = 13·7Ω

Half secondary resistance = 125Ω, i.e., 0-350V

Reflected primary resistance = 26·8Ω

Impedance ratio = 1·96

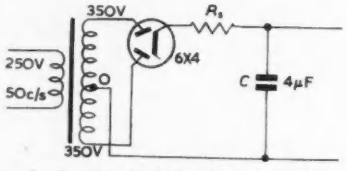


Fig. 5. Rectifier circuit for the example given.

VALVE CV493

From Table 1, this valve is limited by the peak anode current rating; use equation (1) and graph Fig. 2.

Diode resistance at 207mA is 200Ω.

Valve ratings:

$$I_L = 68\text{mA} \qquad I_v'' = 207\text{mA} \qquad I_L/I_v'' = 0{\cdot}328$$

$$A = 0{\cdot}5/0{\cdot}328 = 1{\cdot}52$$

From graph Fig. 2 $t/t_c = 0{\cdot}5$

Supply frequency 50c/s, $t_c = (1/2f) = 10 \times 10^{-3}$sec

$$t = 5 \times 10^{-3}\text{sec} \qquad (t_c - t) = 5 \times 10^{-3}\text{sec}$$

Calculate ripple amplitude from equation (2):

$$\Delta V = \frac{68 \times 10^{-3}\,(5 \times 10^{-3})}{4 \times 10^{-6}} = 85\text{V peak-to-peak}$$

$$V_p = \sqrt{2}V_{rms} = \sqrt{2} \times 350 = 494\text{V}$$

Percentage ripple = (85/494) × 100 = 17·2 per cent of V_p

Since the ripple is less than 20 per cent the value of capacitor used is large enough.

From equations (3) and (4), calculate V_{dc}.

$$ft\pi = 50 \times 5 \times 10^{-3} \times \pi = 0{\cdot}786 \text{ radians} = 45^\circ\ 02'$$

sine $ft\pi = 0{\cdot}7075$

$$\theta = \cos^{-1}\left[\frac{85}{2 \times 494 \times 0{\cdot}7075}\right] - 45^\circ\ 02'$$

$$\theta = 83^\circ\ 02' - 45^\circ\ 02' = 38^\circ$$

$$V_\theta = V_p \sin\theta = 494 \times 0{\cdot}6157 = 304{\cdot}5\text{V}$$

$$V_{dc} = 304{\cdot}5 + (85/2) = 347\text{V}$$

From equation (5) calculate V_a''

$$V_a'' = V_p\left[\sin\alpha - \sin\theta - \frac{(\alpha - \theta)\,\Delta V}{\pi t/t_c\,V_p}\right]$$

$$\cos\alpha = \frac{85}{494\pi \times 0{\cdot}5} = 0{\cdot}1093$$

$\cos\alpha = 0{\cdot}1093 \qquad \alpha = 83^\circ\ 43' = 1{\cdot}4611$ radians

$\sin\alpha = 0{\cdot}9940 \qquad \theta = 38^\circ \qquad = 0{\cdot}6632$ „

$\sin\theta = 0{\cdot}6157 \qquad \alpha - \theta \qquad = 0{\cdot}7979$ „

$$V_a'' = 494\ [0{\cdot}9940 - 0{\cdot}6157 - 0{\cdot}1093 \times 0{\cdot}7979]$$

$$V_a'' = 144\text{V}$$

From equations (6), (7), (8), calculate R_s and its wattage

$$R_T = (V_a''/I_v'') = (144/0{\cdot}207) = 696\Omega$$

$$R_s = 696 - 200 - 26{\cdot}8 - 125 \simeq 352\Omega$$

$$W_{Rs} = 0{\cdot}5 \times 352 \times (0{\cdot}207^2/1{\cdot}52^2) = 3{\cdot}28\text{W}$$

The calculation of half-load voltages will illustrate the second method.

Calculate the value of t/t_c for half-load from the graph, Fig. 4, and equation (9). Start with the assumption that t/t_c is the same as in the full-load case. Successive approximations will lie each side of the correct value; in practice three or four attempts should produce an adequate answer for t/t_c.

Half-load 34mA

$$V_a'/V_p = \frac{34 \times 10^{-3} \times 696}{494} \cdot (1/(t/t_c)) = 0{\cdot}0479\ (1/(t/t_c))$$

Assume $t/t_c = 0{\cdot}5$ as for full load.

HIGH t/t_c BY GRAPH	LOW V_a'/V_p BY EQN.	LOW t/t_c BY GRAPH	HIGH V_a'/V_p BY EQN.
0.5	0.096	0.367	0.13
0.43	0.111	0.397	0.121
0.415	0.116	0.405	0.118
0.41	0.117	0.41	0.117

Thus $t/t_c = 0{\cdot}41$

$t_c = 10\text{msec} \qquad t = 4{\cdot}1\text{msec} \qquad (t_c - t) = 5{\cdot}9\text{msec}$

From equation (2):

$$\Delta V = \frac{34 \times 10^{-3} \times 5{\cdot}9 \times 10^{-3}}{4 \times 10^{-6}} = 50{\cdot}2\text{V peak-to-peak.}$$

From equations (3) and (4) calculate V_{dc}

$$ft\pi = 50 \times 4{\cdot}1 \times 10^{-3} \times \pi = 0{\cdot}6442 \text{ radians } 36^\circ\ 55'$$

$$\sin ft\pi = 0{\cdot}6006$$

$$\theta = \cos^{-1}\left[\frac{50{\cdot}2}{2 \times 494 \times 0{\cdot}6006}\right] - 36^\circ\ 55'$$

$$\theta = 85^\circ\ 9' - 36^\circ\ 55' = 48^\circ\ 14'$$

$$V_\theta = 494 \times 0{\cdot}7459 = 369\text{V}$$

$$V_{dc} = 369 + 25 = 394\text{V}$$

The regulation curves calculated and measured are given in Table 2.

TABLE 2

	NO LOAD		HALF LOAD		FULL LOAD	
	CAL	MEA	CAL	MEA	CAL	MEA
I_v''	—	—	—	—	207	197mA
ΔV	—	—	50.2	48V	85	83V
V_{dc}	494	494	394V	397V	347V	343V

The measurement of output voltage and current presents no difficulty with a normal meter. Ripple voltage and peak

anode current can be measured by means of an oscilloscope. In the peak anode current case, connexion of the oscilloscope across R_s will give the required answer, the only precaution needed being the removal of the power pack earth.

To calculate the worst case of anode current surge which occurs when the anode voltage is applied and the heaters are operating, divide the peak applied voltage by the total resistance.

$I_s'' = (V_p/R_T) = (494/696) = 710\text{mA}$ within the rating. Filter design for the above example would follow well-known methods.

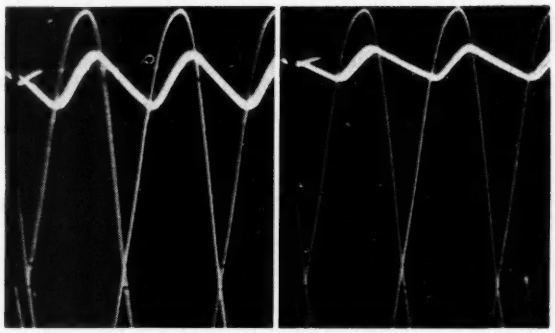


Fig. 6. Double exposure oscilloscope photographs of ripple voltages superimposed on to input voltages, and showing the assumption of linear charge to be reasonable for the example given
Left—full load Right—half load

Double exposure oscilloscope photographs (Fig. 6) of the ripple voltage superimposed on the transformer secondary voltage show the assumption of linear charge to be reasonable in the example given.

In the case of peak inverse voltage limited valves, or under conditions where the peak anode current is limited by the external resistance, the rectifier resistance is unknown. A reasonable assumption of rectifier resistance can be made from Fig. 3 or the specification and corrected if necessary on a second attempt.

Acknowledgments

Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this article. Crown copyright is reserved.

Appendix

(See Fig. 7)

α is the angle at which V_a is a maximum

V_a' = mean height of shaded area

$$V_a''/V_a' = (I_v''/I_v') \text{ and } t/(1/2f)) = \frac{\pi-\gamma-\theta}{\pi}$$

$$V_a' = \frac{V_p\int_{\theta}^{(\pi-\gamma)} \sin\theta\, d\theta - V_p(\pi-\gamma-\theta)\sin\theta - V_p/2(\pi-\gamma-\theta)\dfrac{\Delta V}{V_p}}{\pi-\gamma-\theta}$$

$$V_a' = V_p[\cos\theta - \cos(\pi-\gamma) - \sin\theta - (\Delta V/2V_p)]$$

$$V_a'' = V_p\left[\sin\alpha - \sin\theta - \frac{(\alpha-\theta)}{\pi-\gamma-\theta}\cdot(\Delta V/V_p)\right]$$

To find the maximum value of V_v differentiate and equate to zero.

$$dV_a/d\alpha = V_p\left[\cos\alpha - \frac{\Delta V}{V_p(\pi-\gamma-\theta)}\right]$$

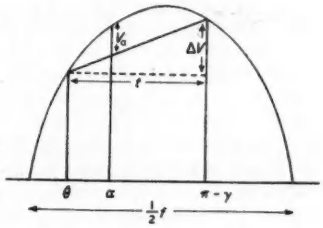


Fig. 7.

$$\therefore \cos\alpha = \frac{\Delta V}{V_p(\pi t/(1/2f))}$$

Now:

$$A = (V_a''/V_a') = \frac{\sin\alpha - \sin\theta - \dfrac{(\alpha-\theta)}{(\pi-\gamma-\theta)}(\Delta V/V_p)}{\dfrac{\cos\theta - \cos(\pi-\gamma)}{\pi-\gamma-\theta} - \sin\theta - (\Delta V/2V_p)}$$

Plot graphs of t/t_c against t/At_c

$t_c = 1/2f$ and $1/f$ for full and half wave respectively.

Calculation of V_θ

$$\text{Sin}(\pi-\gamma) - \sin\theta = (\Delta V/V_p)$$

$$\text{and } (\pi-\gamma) = (t/(1/2f))\,\pi + \theta$$

$$\sin(2ft\pi + \theta) - \sin\theta = (\Delta V/V_p)$$

$$2\cos(ft\pi + \theta)\sin ft\pi = (\Delta V/V_p)$$

$$\cos(ft\pi + \theta) = \frac{\Delta V}{2V_p \sin ft\pi}$$

$$\theta = \cos^{-1}\left[\frac{\Delta V}{2V_p \sin ft\pi}\right] - ft\pi$$

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Ferroxcube Beads for Decoupling Circuits

The inductance and h.f. resistance of a straight wire can be increased appreciably by threading it through a small bead of "Ferroxcube". This fact is made use of in a variety of h.f. decoupling applications, including simple "grid stoppers" to prevent parasitic oscillation, and decoupling circuits in heater leads.

The use of Ferroxcube beads for decoupling heater wiring is particularly attractive in that there is no increase in resistance at d.c. or supply frequencies, though the h.f. resistance may be increased by an appreciable amount by the addition of a single 3mm bead. This large resistive component also reduces the risk of the decoupling elements themselves causing parasitic oscillation, since any tuned circuit formed by them will be heavily damped.

Two types of Ferroxcube bead are available from the Component Division of Mullard Limited—type FX1666 which is suitable for applications involving relatively low radio frequencies, and type FX1667, for high frequency circuits. Both types take the form of short tubes (length, 3mm, inside diameter, 1·2mm, outside diameter, 3·5mm). The beads are put into circuit simply by slipping them over the relevant leads. They can be held in place if necessary by pieces of sleeving. More than one bead can be used to obtain increased inductance and loss resistance.

A Constant Voltage Amplifier and Oscillator

By G. N. Patchett*, Ph.D., A.M.I.E.E., M.Brit.I.R.E., M.I.R.E.

The apparatus will operate as an amplifier or as an oscillator with a constant voltage output. The output voltage remains within 0·1 per cent for large changes of input voltage, from no load to full load and for large changes of supply voltage. The apparatus may be used for instrument calibration or for any purpose where a constant voltage supply is required

THE apparatus to be described† was designed to give a voltage, or current output, which would be constant to a high degree of accuracy and be almost independent of reasonable supply voltage changes and load conditions. The apparatus may be operated in one of two ways:—(a) As an amplifier, being fed with a voltage of the frequency corresponding to that required on the output. In this case the output voltage is practically independent of the input voltage fed to the amplifier, within large limits

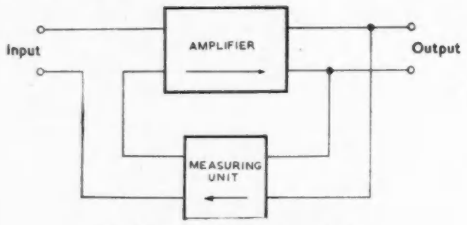

Fig. 1. Basic principle of amplifier

and also independent of large changes of power supply voltage and load changes from no load to full load.

(b) As an oscillator, the frequency of the voltage output being determined by the constants of the circuit. In this case the magnitude and frequency of the output are constant within close limits and nearly independent of supply voltage changes and load changes from no load to full load.

The principle of the device is shown in Fig. 1, where the apparatus is shown as an amplifier and connected so as to maintain a constant output voltage. The output of the amplifier is connected to the measuring unit which gives no output when the voltage is correct but, a relatively large output if the output voltage of the amplifier departs from its predetermined value. The output from the measuring unit is connected in series with the amplifier input so that the actual input to the first valve is the sum, or difference, of the amplifier input and the output of the measuring unit. Instead of actually being connected in series with the input it may be connected in other ways so that the output of the measuring unit adds, or subtracts, from the input to the amplifier. The sense of the output of the measuring unit is such that, if the output falls, the output voltage of the measuring unit adds to the input so increasing the actual input to the first stage and, hence, the output of the amplifier, so tending to restore the output voltage to normal. Under these conditions the feedback is, of course, positive, tending to increase the overall gain of the amplifier. If the output voltage of the amplifier increases above normal the phase of the output of the measuring unit is reversed so that it opposes the input, so decreasing the output and tending to restore it to its correct value. In this case the feedback is negative and, therefore, decreases the effective amplification of the amplifier.

Although it is possible to use any suitable measuring unit in this circuit the main point of the apparatus is the use of a thermistor bridge which has the advantage of

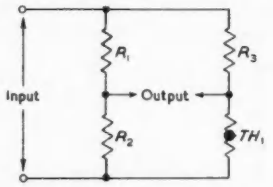

Fig. 2. Thermistor bridge measuring unit

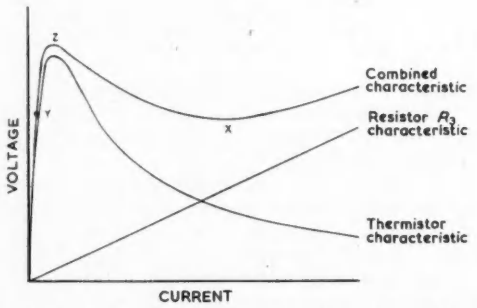

Fig. 3. Current-voltage characteristics of thermistor and thermistor bridge

producing a large output voltage for a small change of input voltage[1,2,3]. The bridge is composed of three linear resistors R_1, R_2 and R_3 and one directly heated thermistor TH_1, as shown in Fig. 2. The current-voltage characteristic of the thermistor is shown in Fig. 3, from which it will be seen that, over a large portion of the characteristic, the slope resistance is negative. On the same figure is shown the characteristic of R_3 (a straight line) and also the combined characteristic of the thermistor and resistor R_3 in series. This combined characteristic is, of course, the voltage current characteristic of the right-hand side of the bridge, the left-hand side being a linear characteristic. It will be seen that, at point x, the characteristic is horizontal over a small region and, therefore, the current in the circuit may change, and hence the output of the bridge will change, without a change of input voltage. The ratio of change of output voltage to change of input voltage, is called the figure of merit and with this bridge, operating with small changes, it approaches infinity. The figure of merit is difficult to measure in practice but a value of about 50 may be obtained. This is a great improvement over bridges using other types of non-linear element where the figure of merit is usually less than unity.

* *Bradford Technical College.*
† *Prov. Patent* 5981

If the input to the amplifier is reduced below a certain value the feedback is then positive. If the circuit is designed correctly the amplifier may then be made to operate as an oscillator having the same output characteristic, but with a frequency determined by the amplifier circuits.

It is obvious that a large number of different amplifier and oscillator circuits may be designed around this principle, but only one will be described in this article. The amplifier to be described was designed to operate at 1 000c/s and give a constant voltage output of approximately 230V, with a maximum power of 10W. The circuit of the complete amplifier, excluding power supply, is shown in Fig. 4. The amplifier itself consists of the first stage V_1 fed from the input transformer T_1. The anode load of this stage consists of a tuned circuit L_1C_1 tuned, in this particular case, to 1 000c/s. This stage is followed by a phase-splitter valve V_3 which feeds the two amplifier valves V_4 and V_5 in push-pull. These two valves feed, in turn, the two output valves V_6 and V_7, which feed the output terminals through the output transformer T_2. This amplifier is fairly conventional and may be replaced by any suitable amplifier circuit.

The output of the amplifier is fed to the measuring unit bridge through transformer T_3, to give a suitable voltage for the bridge. The bridge is similar to that previously described[1,2,3], two arms of the bridge being formed by R_3 and the thermistor TH_1. Instead of using resistors for the other two arms they are replaced by a suitable tap on the transformer secondary. As the bridge is temperature sensitive, a temperature compensating circuit is added, consisting of resistor R_4 and thermistor TH_2. Thermistor TH_2 is a large type thermistor where the self heating is small. On a rise of ambient temperature the resistance of TH_2 decreases, so decreasing the voltage fed to the bridge. This is arranged to correspond with the decrease in the balance voltage of the bridge, so that the whole circuit remains in balance for a fixed primary voltage applied to transformer T_3, over a reasonable temperature range. To compensate for some quadrature output from the bridge due to the thermal inertia of the thermistor and due to the stray capacitances, a suitable capacitor is placed across R_3 and adjusted until the quadrature output is zero. The output from the bridge is fed to the potentiometer VR_1 which can be adjusted to give the correct amount of feedback. The output from VR_1 is then fed, in series with the secondary of the input transformer T_1, to the input valve V_1.

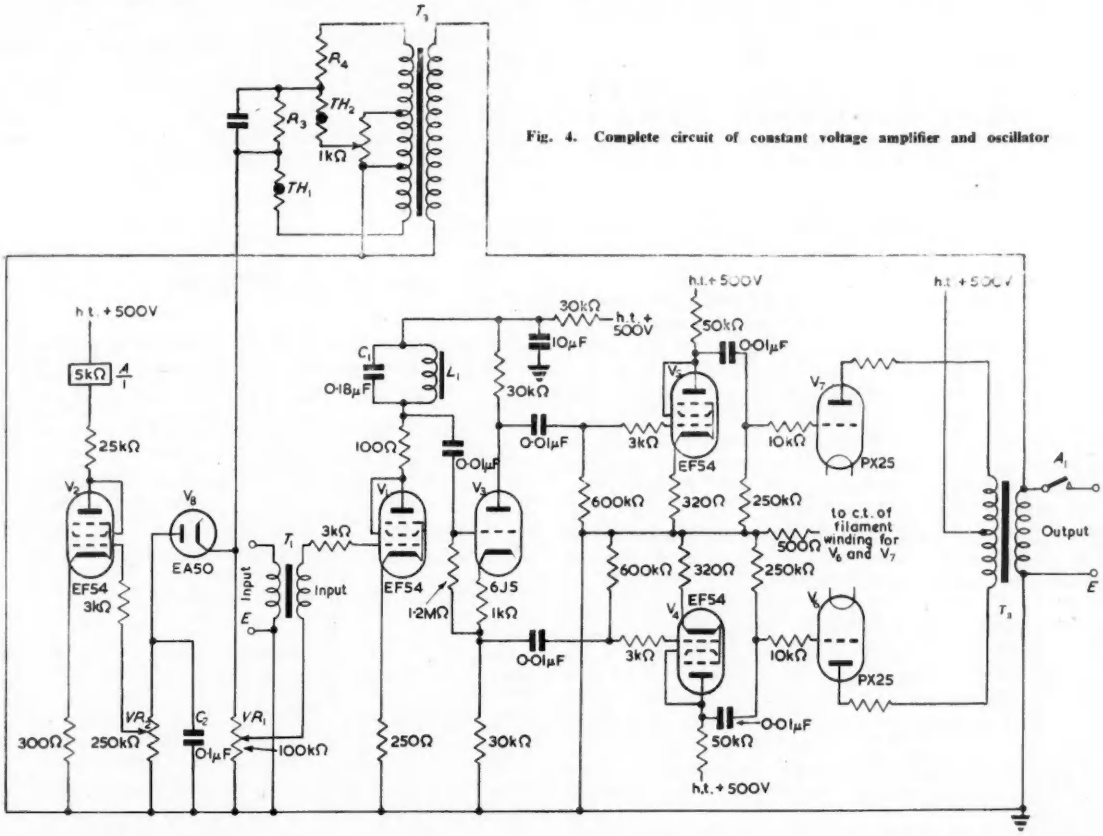

Fig. 4. Complete circuit of constant voltage amplifier and oscillator

It is necessary to use a tuned circuit in the anode of valve V_1, or some other means of making the amplifier frequency selective, for two reasons:—

(a) The feedback loop contains two transformers and it is difficult to maintain the circuit stable when the negative feedback is large i.e. when the input voltage is large.

(b) When the feedback becomes positive, as it must when the input voltage decreases below a certain value, rather violent oscillation takes place when the positive feedback exceeds a certain value, unless the circuit is reasonably frequency selective in which case the oscillations are of

a steady value, giving the same output as in the case of the operation as an amplifier.

This feature could probably be omitted if the range of input voltage was restricted so that the circuit never became on oscillator and the negative feedback never became excessive.

On first switching on the amplifier the thermistor is cold and will operate at a point such as Y, if the voltage remains constant (see Fig. 3). When the bridge operates at this point the phase of the bridge output is such as to increase the output of the amplifier and, under no load conditions, the voltage will rise until point Z is reached when the bridge operating point will move rapidly to the stable point X. To prevent this rise in output voltage being applied to the output terminals a relay *A* is incorporated. The output from the bridge is rectified by the valve V_3 and smoothed by C_2 so as to give a negative voltage proportional to the bridge output. A portion of this voltage (being controlled by the potentiometer VR_2) is fed to valve V_2, in the anode circuit of which is the coil of the relay *A*. When first switching on, the output from the bridge is large and valve V_2 is biased to cut-off and the relay is not energized. The output terminals are, therefore, disconnected from the output transformer by contact A_1. When the bridge has warmed up and reached its correct operating point X, the output is small and there is not sufficient voltage to maintain V_2 cut off. Accordingly relay *A* is energized and the transformer T_2 is connected to the output terminals. Thus, no overvoltage is applied to the output terminals and the starting is simple and reliable.

Having described the circuit and principle of operation, the performance of this particular amplifier will be considered. The figures have been obtained by measuring the output voltage with a thermocouple meter on which a change of 0·1 per cent could be detected. The resistance of the meter circuit was 73kΩ and the no load readings included the loading of this meter circuit.

Output Voltage—Input Voltage as an Amplifier

The nominal input voltage is 0·4V at 1kc/s. The change of output for a change of input of +10dB to −20dB was found to be less than 0·1 per cent. With an input of +20dB the output rises by about 0·4 per cent and, if the input is increased to about 12·5V, the output rises still further but operates relay *A* and disconnects the output terminals from the output transformer, so protecting any apparatus fed from the amplifier.

When the input is reduced below −20dB the amplifier becomes an oscillator but the output voltage still remains with 0·1 per cent of the output at 0dB.

In other words, the output remains within 0·1 per cent and the apparatus operates as an amplifier over an input voltage range of 30dB, a change of 32 times on voltage. The variations of voltage are therefore reduced by a factor of 32/0·001 or 32 000.

Output Voltage—Load

When the equipment is operated as an amplifier with an input between +10dB and −20dB and also as an oscillator, the output is constant within 0·1 per cent from no load to the full output of 10W.

Output Voltage—Supply Voltage

OSCILLATOR ON NO LOAD

The nominal supply voltage is 230V but this may be changed from 130V to 250V without the output voltage changing more than 0·1 per cent. When the input voltage is increased to 260V the output was found to rise by 0·1 per cent.

AS AN OSCILLATOR ON FULL LOAD

The output voltage now changes by less than 0·1 per cent when the supply voltage is changed from 170V to 260V. The range of voltage is now less due to the drop in h.t. voltage and filament voltage which prevent the amplifier giving an output of 10W.

As an Amplifier with an Input of 0·4V

NO LOAD

The output is within 0·1 per cent for supply voltage variations from 120V to 260V.

FULL LOAD

The range of variation is reduced, but the output is still constant to 0·1 per cent for an input variation from 170V to 260V.

Distortion

This is the same as an amplifier or an oscillator and is largely determined by the output stage.

NO LOAD

Less than 1 per cent, being about 0·25 per cent second harmonic and 0·65 per cent third harmonic.

FULL LOAD

Less than 3 per cent, being about 0·5 per cent second harmonic and 2·5 per cent third harmonic.

Due to the fact that the amplifier is frequency selective the output waveform may be much better than the input and a fairly good sine wave is produced when the input is fed from a square wave source.

Change of Frequency as an Oscillator

NO LOAD

The output frequency changes by about 1c/s when the supply voltage is changed from 140V to 250V.

FULL LOAD

In this case a change of about 1c/s takes place when the supply voltage is changed from 180 to 250V. The effect of changing the load from no load to full load is to change the frequency by 2 to 3c/s.

Effect of Change of Input Frequency as an Amplifier

The amplifier was designed to operate with an input frequency of 1kc/s and, if the frequency departs from this, the performance is not as good. If the input voltage is between 0 and +10dB the amplifier will work with the same performance as quoted, from about 900 to 1 100c/s. When the input is reduced below 0dB the amplifier tends to operate as an oscillator when the input frequency departs appreciably from 1kc/s.

These figures show that the performance is quite remarkable since the output voltage is within 0·1 per cent for any input voltage from zero to 4V, from no load to full load and for any supply voltage from 180 to 250V, or even greater on light loads.

Although the amplifier was designed for a fixed frequency of 1kc/s there is no reason why this frequency cannot be changed to any other frequency over a large range, by alteration of the tuned circuit of valve V_1. There

is also no reason why the frequency should not be made variable and, in place of the tuned circuit, an *RC* network could be used to give the amplifier suitable frequency selective properties. At low frequencies the output from the thermistor bridge contains some third harmonic and it would probably be necessary to include a parallel-*T* filter in the output of the measuring unit, tuned to this frequency (see ref. 1 and 2).

The apparatus was designed for instrument calibration but obviously, there are a large number of applications where a constant voltage supply of a particular frequency are required. The output frequency can, of course, be made a standard frequency by feeding the amplifier from a suitable frequency source, the resulting output being a supply of constant frequency and voltage. The output voltage may be made any convenient value by changing the ratios of transformers T_2 and T_3, and the amplifier may be used as a low voltage source to feed, for example, a lamp so as to maintain constant light output. This is often difficult with normal d.c. stabilizers owing to the large current and low voltage. By using a high enough frequency any question of flicker can be overcome. If it is desirable to maintain a constant current output in place of the constant voltage the circuit can easily be modified. In this case the primary of transformer T_3 should be placed across a resistor in series with the load and the relay *A* should be made so that it shorts the output terminals when in the de-energized position.

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New Facilities for Research on Cathode-ray Tubes

The successful production of television cathode-ray tubes on a large scale calls for continuous research into the materials and processes used in their manufacture. Some of the most intriguing problems in this field are provided by the production of the fluorescent screen. For this reason, enlarged facilities, which incorporate a number of interesting new features, have recently been built at the Wembley Research Laboratories of The General Electric Co. Ltd, for intensive work on screening problems.

There are several reasons for increased research activity along these lines at the present time. There are, of course, the aims of the manufacturer to reduce the cost of the screening processes, to use better materials in those processes and to provide cheaper cathode-ray tubes. Then, also, the standards of screen quality required have risen considerably during the last few years. The viewer has become accustomed to larger screens that are completely free from defects. Such characteristics as brightness and picture quality are also continually being improved. As screen sizes increase, these requirements become more difficult to meet. Clearly, any increase in screen area also increases the chances of obtaining a screen defect. Further, not all screening processes used for making existing tubes can be used for the larger sizes without modification. Some of the properties, such as the viscosity and surface tension of the materials used, are critical, so that the process may have to be re-examined before it can be applied to the manufacture of larger tubes.

The development of 21in and 24in screens for future manufacture has made it necessary to increase the size and scope of the research facilities required for this work. Such extensions are now able to accommodate the larger tubes themselves and the greater sizes of the experimental batches to be processed. They will enable large scale experiments to be carried out for testing both the methods and the materials used for screening the tubes. Further work in the new laboratories is devoted to the investigation of more fundamental aspects of filming and screening processes. Among these are investigations into the increased screen efficiency, less tendency towards electron burn, improved colour characteristics, or a combination of these properties.

During the manufacture of the screen, it is vitally important that no unwanted impurities enter the cathode-ray tube bulb or the materials used for screening. As little as 1 part per million of copper, for example, can adversely affect the fluorescent properties of some powders, while even one minute particle of dust would cause a screen defect.

One of the primary considerations in designing the new screening rooms has therefore been the provision of a clean atmosphere. Filtered hot and cold air are brought in through two ducts and mixed to give an atmosphere of the required temperature. This degree of temperature control will enable experiments to be carried out on the effect of temperature on the various screening processes used. Later work may also include the analysis of samples taken from the atmosphere, so that the effect of atmospheric conditions in general (including temperature, humidity and pollution) can be gauged.

Although atmospheric conditions are easily controlled in the laboratory, some of the equipment used there may be open to the atmosphere. In the factory, on the other hand, the corresponding automatic equipment used for mass production would be completely sealed and thus more independent of atmospheric conditions. The overall conditions of cleanliness in the laboratory will therefore approximate closely to those easily achieved in the factory itself.

The development of a new manufacturing process can be broadly divided into two parts, the technique itself and the materials to be used in it. A fluorescent screen is prepared in two stages, known respectively as screening and filming. In the former, the fluorescent powder is allowed to settle on to the inside of the glass bulb through a cushioning liquid. All excess liquid is then allowed to drain off by decanting. Since the phosphor screen at this stage has a granular structure, it is necessary to bridge the gaps by covering the powder itself with a thin skin or foil before the reflecting aluminium coating is applied by evaporation. In this process, known as filming, a thin film of an organic liquid is made to cover the phosphor in one of several ways. For example, the irregularities in the screen structure of the phosphor can be filled with water, which is then frozen. A solution of the film-forming material in a volatile solvent is then made to flow over it and the solvent removed by evaporation. After the film has completely solidified, the temperature is raised, the ice melted and the resulting water dried out of the screen by evaporation.

Alternatively, in the flow filming method, after filling in the structure of the phosphor screen with water, a solution of the film-forming substance may be allowed to flow over it. The film is then dried out as before.

In yet another method, the flotation process, the film is formed on the surface of a water pool covering the screen. This is achieved by dropping a small quantity of a solution of the film-forming material, in a volatile water-insoluble solvent, on the surface of the water and allowing it to spread. When the film has set, the water is syphoned off or decanted away and the film thereby deposited on the screen. Any residual water held in the screen can then be removed by evaporation through the film.

Experimental work on both the flow filming and the flotation filming processes is in progress at the present time.

Running-Voltage/Current Characteristics of Some Glow-Discharge Tubes

By F. A. Benson*, M.Eng., Ph.D., A.M.I.E.E., M.I.R.E, and G. Mayo*, B.Eng.

Typical running-voltage/current characteristics of nine types of recently developed or newly designed glow-discharge tubes are presented and discussed. It is concluded that the kind of gas filling is a most important factor in determining the shape of such characteristics and hence the tube behaviour. Some information is also given about running-voltage drifts which occur after switching on a tube and after changing the tube current.

DETAILED investigations have been carried out during the past few years by several independent experimenters to determine the characteristics and limitations of certain glow-discharge voltage-regulator tubes[1-7]. A number of new types have been produced fairly recently and many of the early types have been modified or redesigned in an attempt to obtain more stable characteristics. Some detailed measurements have been made on several of these tube types, namely, 90C1, 150B2, KD63, QS70/20, QS75/60, QS83/3, QS92/10, G400/1K and QS150/15. Typical running-voltage/current characteristics of these tubes are presented and discussed in this article and some information is given about initial drifts in running voltage and drifts which occur on changing tube current.

The gas filling seems to be a most important factor in determining the shapes of the running-voltage/current and other characteristics and hence the tube behaviour.

Measurements

Each tube was operated in turn from a stabilized variable voltage supply through a suitable series resistor. A meter in the cathode lead was used to measure tube current. Decade resistance boxes across the tube stepped down the running voltage so that it could be recorded accurately by means of a potentiometer.

After the initial drift was complete the running voltage was measured over the specified current range both for increasing and decreasing currents. In cases where hysteresis was present in the characteristic, readings were taken very close together to determine the exact shape of the curve. Some drift in running voltage was noticeable at each change of current and this was most serious at the higher currents as might be expected from previous work on initial drifts[4]. In all cases, drifting was allowed to continue until readings were steady. Running-voltage/current characteristics were also observed on an oscillograph at a frequency of 20c/s using a method previously described[8] and some interesting oscillograms were collected.

Experimental Results

Typical running-voltage/current characteristics are shown in Figs. 1 to 9.

Drifting of running voltage was always opposite in sign during increasing and decreasing current changes. In the cases of types QS83/3, 90C1, QS92/10 and QS150/15 the initial drifts were small and complete in less than 3 minutes and the drifts at each current change were also very small. The initial drift for the 150B2 tube is complete in about 5 minutes. The G400/1K tubes have rather large and prolonged drifts, while the majority of KD63 tubes show initial drifts of about 20 minutes' duration, and give random voltage fluctuations indefinitely. The running voltage of QS75/60 tubes drifts for 3 to 5 minutes after a change of current and there is appreciable drift in the case of QS70/20 tubes when the current is changed, although the initial drift is small and the running voltage becomes stable in less than 3 minutes.

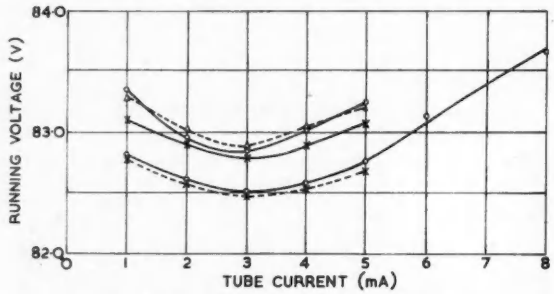


Fig. 1. Typical running-voltage/current characteristics for tubes type QS83/3

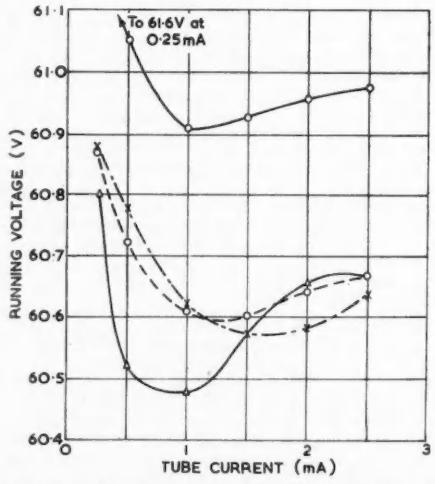


Fig. 2. Typical running-voltage/current characteristics for tubes type KD63

Tube types QS83/3, QS75/60 and QS70/20 are known to contain only neon with a small percentage of argon. It is interesting to see from Figs. 3 and 7 that the characteristics of two of these types, namely QS70/20 and QS75/60, are either straight lines or very nearly linear. The low-current tubes type QS83/3 have V-shaped charac-

* *The University of Sheffield.*

teristics, but this is due to the fact that the specified current range is at the low end of an otherwise straight curve. This is clearly seen on Fig. 1 where one tube has been overloaded and the curve plotted up to a current of 8mA. Some high-current neon tubes show this phenomenon at very-low currents. These results seem to suggest that the KD63 and 90C1 types, whose characteristics are shown in Figs. 2 and 4 respectively, contain only neon and argon.

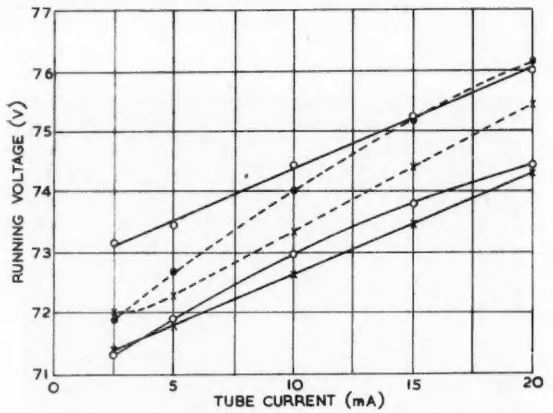


Fig. 3. Typical running-voltage/current characteristics for tubes type QS70/20

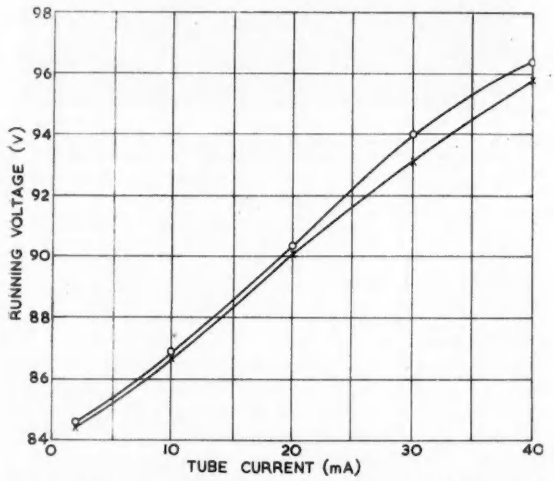


Fig. 4. Typical running-voltage/current characteristics for tubes type 90C1

Tube type QS150/15 is known to contain only helium with a small percentage of argon, while type QS92/10 contains helium and neon with a small quantity of argon. Tubes containing helium show hysteresis (see Figs. 6 and 8) and there are rapid jumps in the characteristics coinciding with changes of cathode-glow area. It seems to follow from Fig. 5 that tube type 150B2 also contains only helium and argon.

It should be noted from Fig. 1 that QS83/3 tubes of recent design are remarkably similar and that the regulation is small. Difficulties arise in specifying regulation too because of the V-shape of the curve. Fig. 2 shows that the regulation of KD63 tubes is good and the variations from tube to tube are small. Fig. 9 shows that the G400/1K

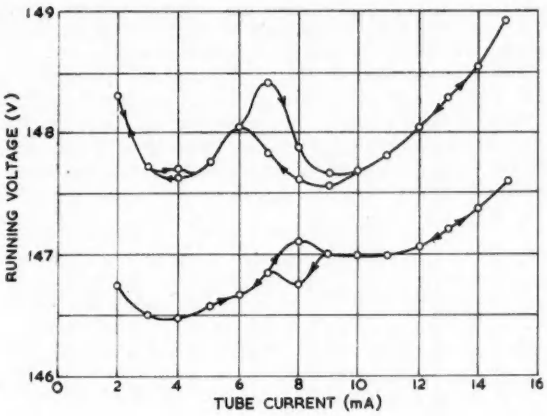


Fig. 5(above). Typical running-voltage / current characteristics for tubes type 150B2

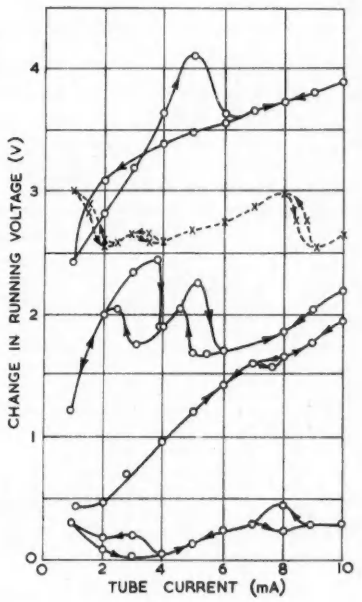
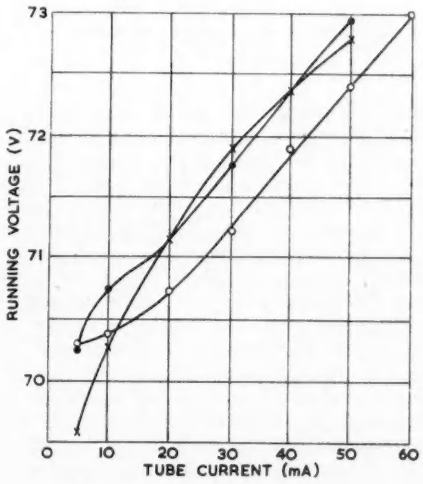


Fig. 6(right). Typical running-voltage / current characteristics for tubes type QS92/10

Fig. 7(below). Typical running-voltage / current characteristics for tubes type QS75/60



tube possesses excellent regulation properties in its specified current range of 2 to 4mA. It will be seen that some of the other types of tubes have large regulations.

The oscillograms of Fig. 10 also show quite clearly the differences in the shapes of the characteristics of the 150B2 and 90C1 tubes. Comparisons of such dynamic characteristics obtained on the oscillograph at a frequency of 20c/s show that there are similarities between corresponding curves. The similarities are not, however, exact.

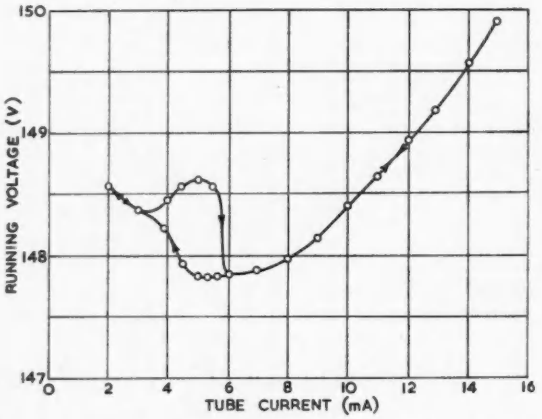


Fig. 8. A typical running-voltage/current characteristic for a tube type QS150/15

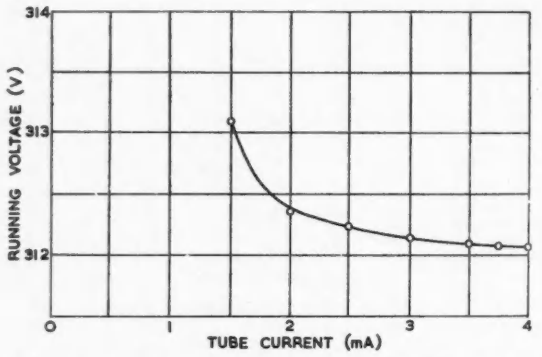


Fig. 9. A typical running-voltage/current characteristic for a tube type G400/1K

Discussion of Results

The marked differences between the characteristics of tubes containing neon and those containing helium are interesting. The differences between such tubes are not, however, limited to the running-voltage/current curves. It has, for example, previously been reported, in a separate paper[9] dealing with the effects of ambient-temperature variations on most of the above types of tube, that the gas filling influences greatly the shape of the running-voltage/temperature curve of a tube and is an important factor in deciding whether a given tube will show a positive or a negative temperature coefficient. It has now been established that most tubes containing neon and argon with no helium have only negative temperature coefficients and the running-voltage/temperature curves are all linear or nearly so. Tubes which contain helium, however, exhibit minima in their running-voltage/temperature characteristics. There is also some evidence that the kind of gas filling in a glow-discharge tube is one important factor in governing the shape of its impedance-frequency characteristic.

The results obtained are difficult to explain. They seem to suggest, however, that there are larger quantities, or different kinds, of impurities in tubes containing helium. From the curves of Fig. 6 it would appear that no very special precautions are taken in preparing and cleaning the cathode surface of QS92/10 tubes.

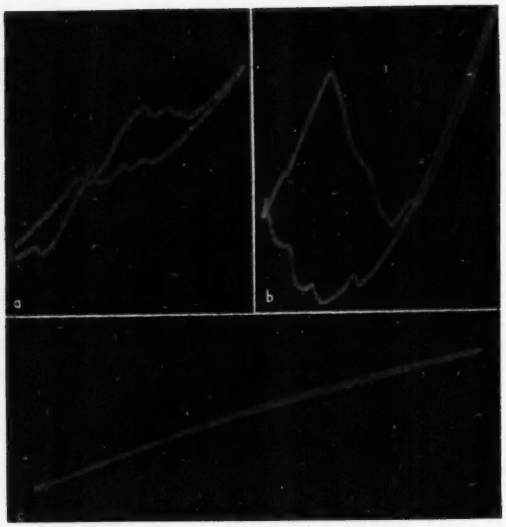


Fig. 10. Typical running-voltage/current characteristics of glow-discharge tubes as observed on an oscillograph at a frequency of 20c/s
(a) and (b) 150B2 tubes operating at a d.c. of 10mA and with an estimated a.c. swing from 5 to 15mA
(c) 90C1 tube operating at a d.c. of 20mA and with an estimated a.c. swing from 1 to 40mA

It should be pointed out that the measurements described in this article were carried out prior to April 1954.

Acknowledgments

The authors wish to thank Mr. O. I. Butler for laboratory facilities in the Department of Electrical Engineering at the University of Sheffield. They also wish to acknowledge the kindness of the English Electric Valve Co. Ltd, Ferranti Ltd, Mullard Ltd, and Standard Telephones & Cables Ltd, in supplying some of the tubes for examination.

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A Magnetic Tape Recorder for Electrophysiology

By P. E. K. Donaldson,* M.A.

A simple apparatus is described, using readily available commercial components, for recording an electrical signal continuously for a period of up to 20 minutes. The usable dynamic range is 60dB and the frequency response 0 to 2kc/s. This spectrum is useful in electrophysiological work, and it is hoped that the recorder may find application in other fields.

THE usual method of recording the result of an electrophysiological experiment is to photograph with continuously-moving film the screen of a cathode-ray oscilloscope. The method has the advantage of good fidelity and the apparatus is simple. On the other hand it is not possible quickly to re-examine a piece of record which has just been secured. Further, there occur in physiology highly significant events which it may not be possible to evoke with a stimulus at a particular time. Film being quite expensive, there is therefore a risk that such an event will be missed because the camera was not switched on, or, at the other extreme, that yards of film will be exposed in valueless record. Clearly, there are occasions in which it would be helpful to have an intermediate stage of quick-access storage, using a medium which is not consumed in the process, and an obvious choice lies in magnetic tape.

Frequency Response Required

Generally speaking, the fastest event with which one has to deal in electrophysiology is the mammalian action potential. To reproduce the waveform of this accurately requires the inclusion of frequencies up to 10kc/s. Fortunately, for the kind of work for which this recorder is used, accurate reproduction is not necessary, and a response up to 2kc/s is sufficient. The action potential lasts about half a millisecond, so one is preserving the fundamental frequency and losing the harmonics. A typical slow bioelectric potential is the amphibian ventral root potential, which may last up to half a second. Bearing in mind the difficulties encountered with long time-constant a.c. coupled circuits due to paralysis times, it was felt advisable to aim at an instrument going right down to d.c.

Sensitivity Required

The usual procedure for electrophysiological recording in this laboratory is to use a pre-amplifier and a main amplifier, the main amplifier being part of the oscilloscope. It is therefore convenient if the recorder can be connected to the output of the pre-amplifier, in parallel with the oscilloscope, and it must be sufficiently sensitive to be fully loaded by the order of output amplitude that the pre-amplifier will give. Very roughly, one encounters bioelectric potentials in the range 50μV to 50mV. Taking the geometric mean as a typical signal to be recorded, gives 1½mV. The pre-amplifiers used in this laboratory have a gain in the region of 750, so the typical signal enters the recorder at just over 1V. The 50mV signal will require thirty-two-fold attenuation, and the 50μV signal will emerge from the recording process sufficiently recognizable if it is 3 to 4 times the peak-to-peak noise added by the recorder. This noise should therefore be equivalent to a 10mV signal at the recorder input, or less.

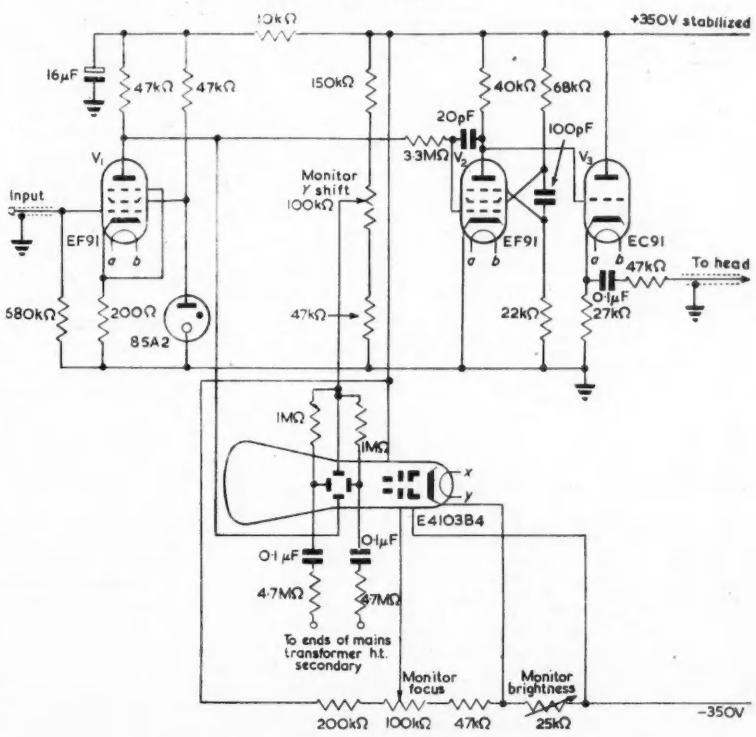
Other Considerations

From the point of view of cost, the machine should use, if possible, a standard type of tape deck and ordinary commercial tape. The tape speed should be as low as possible, in order to secure the maximum running time. Non-linearity distortion should be held down to such a point as to be imperceptible by direct visual inspection of known waveforms on the cathode-ray oscilloscope.

Design

After some preliminary experiments, it appeared that a

Fig. 1. The recording channel



* *Physiological Laboratory, Cambridge.*

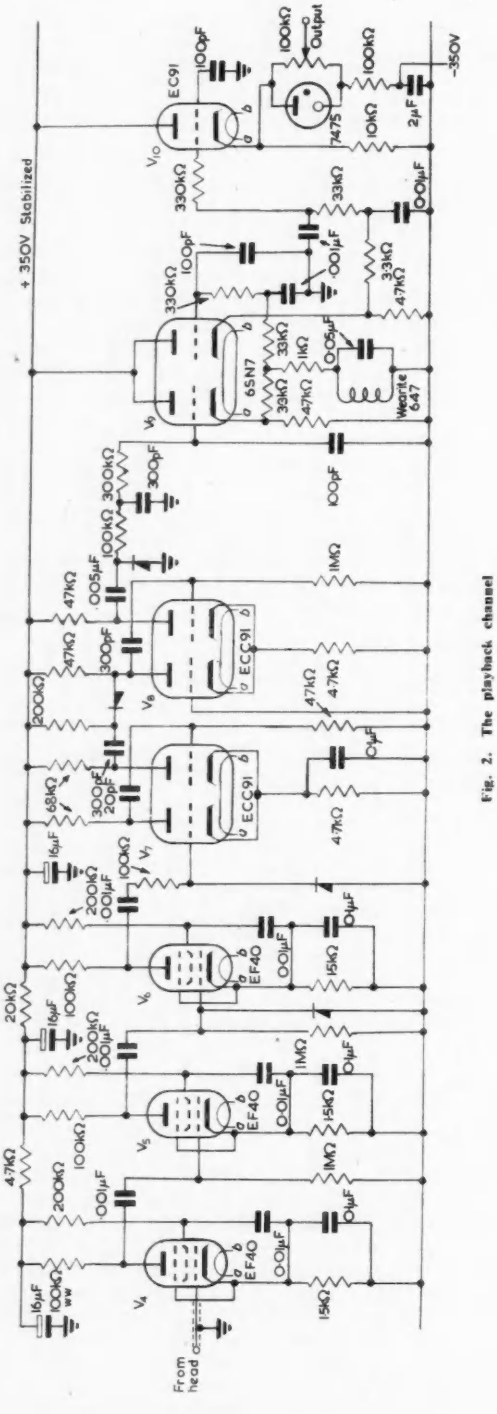


Fig. 2. The playback channel

satisfactory approach lay in the use of frequency modulation. A tape recorder using this system has been described by Molyneux[1] and the instrument to be described is based on his circuit. Molyneux's recorder is for cardiography, and an upper frequency response of 100c/s permits the employment of quite a low carrier frequency, well within the normal range of a conventional tapedeck. To handle a modulation frequency of 2kc/s, the carrier has to be at least five times this if the problem of filtering modulation from carrier after playback is not to be too great. Moreover, for good signal-to-noise ratio the deviation should be wide, but this aggravates the problem of filtering during the extreme downward swings of carrier frequency, unless the mean carrier is made yet higher. Yet this is not easy, because of the record-playback head losses at such frequencies, and there is self-demagnetization of the tape due to the short-magnet effect unless the tape speed is

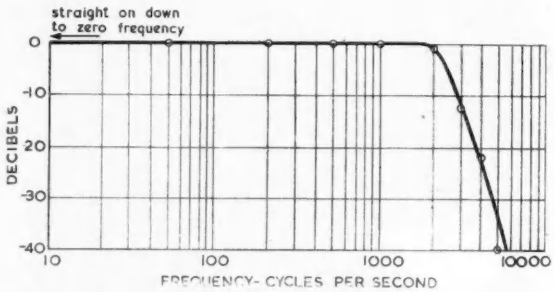


Fig. 3. Measured frequency characteristic of low-pass filter and of the complete apparatus

high. The compromise values adopted are: tape speed 12in/sec. Mean carrier 15kc/s. Deviation 5kc/s, maximum. With this arrangement the amplitude of the signal received back from the tape is extremely erratic, but it never disappears altogether, and with a lot of amplification and very severe limiting it can be made manageable.

Description

Referring to Fig. 1, the recording channel, a stage of d.c. amplification feeds the built-in monitor tube (supplied with a sinusoidal 50c/s time-base) and the v.f.o., which is a Miller-transitron with a very short flyback time. There is then a buffer stage, and thereafter the signal passes through screened cable to the recording head via the recording resistance. No h.f. bias is required, but h.f. erase power is supplied to the erase head in the normal manner.

Fig. 2 shows the playback channel. There are 3 stages of amplification, after which the signal is passed to V_{7a}, where negative-going excursions of the wave are clipped by the crystal diode, and positive going excursions by grid current in the valve. An amplified, limited, square wave train appears at the anode which is differentiated, then amplified by V_{7b}. Negative-going pips only are passed by the series crystal diode to trigger the flip-flop V_8. Thus the output at V_{8b} anode is a chain of identical positive-going pulses, whose spacing depends on the modulation. If these are passed through a low-pass filter, the modulation is regained.

The filter performance is shown in Fig. 3, and this is the frequency characteristic of the apparatus as a whole. It will be seen that the output is well maintained up to 2kc/s, after which it falls steeply. Only one inductor is used, and this is a standard commercial component, a

Wearite type 647. The filter is cathode-followed out to a simple arrangement for setting the d.c. bias of the output to zero.

Performance

Using a Wright & Weare tapedeck with a special pulley on the motor shaft to raise the tape speed to 12in/sec, the apparatus has a substantially flat frequency response from zero to 2kc/s. Maximum deviation is achieved with an input amplitude of 1V peak-to-peak. Signals undergo amplification over the recording process—about 6dB, and it should be remembered that there is also a reversal of polarity. If the machine be loaded fully with a sine wave input at any frequency between zero and 2kc/s, and the output inspected on an oscilloscope, there is no perceptible non-linearity distortion. At the time of writing, the apparatus has been in use for 6 months and no faults have developed.

Conclusions

The need has been suggested for an intermediate storage system in electrophysiological work, and the requirements of such a system outlined. A machine which fulfils these requirements has been described.

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New Applications for Photocells in Collieries

Mechanization and the modern trend towards fully automatic supervisory and control systems have led to a much wider use in industry of the photocell. In collieries, in particular, photo-eelctric equipment is now finding many new applications and recent examples include such diverse functions as cage-positioning, checking the closing of skip doors, indicating slack rope when a cage is resting on keps, automatically controlling artificial lighting, and providing a warning system for an aerial ropeway. In all these instances the photo-electric equipment makes for safer, more efficient and more economical working.

The following are typical installations and have been made with standard photo-electric equipment supplied by the General Electric Co. Ltd.

Cage-positioning

At Llay Main Colliery in North Wales, near Wrexham, a photo-electric signalling system has recently been installed to speed up coal-winding operations. When a cage reaches the unloading position at the top of the shaft, a lug on the side of the cage intercepts a light-beam shining on a photocell. This at once causes an indicator lamp to light in the winder house, so that the winding engine operator is able to check the cage at the right level. Though the shaft is one of the deepest in the country (it is 1005 yards deep) and deck-changing is employed (that is the two decks in the cage are unloaded successively at the one level so that when one deck has been unloaded the cage has to be raised and repositioned before the other deck can be unloaded) 45 runs an hour are obtained using the photo-electric indicator as a cage-positioning guide.

Both the cages used in the main shaft accommodate four mine cars, two on the top deck and two on the lower deck. The empty cars are loaded into the cages at the top of the shaft, sent down, filled and then returned to the top. The mine cars run on rails and the cages have to be positioned so that the rails in the cage itself are in line, to within $\frac{1}{2}$ inch, with the rails on the landings.

Until recently both decks of the cages were unloaded simultaneously on two different levels at the top of the shaft. This system was quick, but necessitated two separate loading and unloading levels at the top of the shaft, each of which had to be staffed individually. Accordingly it was decided to do away with the lower of these two levels and introduce a deck-changing system, in which the two decks would be unloaded successively at one level. This system, however, necessitates the cage being repositioned after one deck has been unloaded so that, in effect, the cage must be positioned twice under the new system where it had only to be positioned once with the old system. This would have led to a considerable increase in the time spent in positioning the cage with a corresponding large drop in output if an improved positioning system had not been introduced.

A photo-electric relay and associated lamphouse have been installed on the side of the shaft, the beam from the lamphouse falling on the photocell. The signal resulting from this is amplified and keeps a relay in the "open" position. A rubber lug is mounted on the side of the cage in such a position that it will, as the cage rises, intercept the light beam just as the deck of the cage comes flush with the approach rails. As soon as the light beam is interrupted, the photo-electric signal ceases and the relay closes. This completes a circuit which incorporates an indicator lamp located in the winding shed in front of the winder operator. The indicator lamp is illuminated and the operator at once stops the winder, knowing that the cage is now in position for unloading and loading.

After the two filled wagons have been removed from the first deck and replaced with two empty wagons, the banksman at the head of the shaft presses a button which gives a code ring on a bell in the winding shed. The winder operator then sets the winder moving again and the cage is drawn slowly up until a second rubber lug, mounted directly below the first on the side of the cage, interrupts the beam from the lamphouse to the photocell and actuates the indicating lamp once again. This second lug is located so that, when this happens, the second deck is flush with the approach rails and the remaining two filled wagons can therefore be removed and replaced with two empty wagons. After this has been done, the operator at the head of the shaft rings through and the other cage is drawn up as the first cage descends, a similar photo-electric positioning system being used on the other side of the shaft.

A slack rope alarm

At Thoresby Colliery, Edwinstowe, Nottinghamshire, where keps are used for locating the cages, photo-electric equipment has now been installed to ensure that the winding engine will not start to lower the cage until the keps, on which the cages rest while at the top of the shaft, have been withdrawn. If the winding engine paid out several feet of slack rope with the keps still in position, and the keps were then withdrawn, the cage would immediately drop straight down and probably snap the rope.

A photocell and lamphouse are aligned in such a way that metal shutters mounted on the winding drum interrupt the light beam as the drum rotates. When a cage reaches a bank level it actuates a limit switch mounted at the side of the shaft. This brings the photo-electric system into operation and from then on, if the beam is interrupted, an alarm bell rings at once. If therefore the winding engine starts to lower while the cage is resting on the keps, the shutters, as they revolve with the drum and intercept the beam, automatically initiate the alarm. The operator then knows that he must not withdraw the keps until the slack has been taken up again.

Ensuring that skip doors are shut

The Electrical Engineer's Department at Thoresby Colliery has also devised a photo-electric system which prevents the skips entering the shaft if the skip doors are not fully shut. This obviates any risk of a door falling open as the skip descends the shaft.

The skip door when shut is held in position by a catch which drops home. When the door is open and the catch is lifted, a light located on top of the skip comes on and remains on until the catch drops home again. The photo-electric equipment is installed at the top of the shaft so that it is directly opposite this light when the skip is at the top. When a light shines on this photocell the resulting signal is amplified and operates a relay which illuminates a "skip door open" signal in the banksman's cabin and in the winding engine house. As soon as the skip door has shut and the catch has dropped home, the lamp on the skip goes out and the "skip door open" signals are switched off.

The Response Functions and Vector Loci of First and Second Order Systems

By David Morris*, D.Sc., A.M.I.E.E.

(Part 4)

Further Types of Second Order Response Functions and Vector Loci

In this concluding article passive and active second order systems are considered which have a finite response at zero frequency and a quadrature zero-limit at infinite frequency. It is further shown that all second order response loci may be expressed in terms of two basic loci.

Fig. 18 illustrates two passive second order systems that have the same form of response. In Fig. 18(a), if the input is the voltage V_1, and the output is the open-circuit voltage V_2, we may write for sinusoidal conditions:

Response $= V_2/V_1 =$

$$\frac{1/j\omega C + R}{1/j\omega C + R + j\omega L} = \frac{1 + j\omega CR}{1 + j\omega CR + j^2\omega^2 LC} \quad \ldots\ldots (35)$$

* *University College of North Wales, Bangor.*

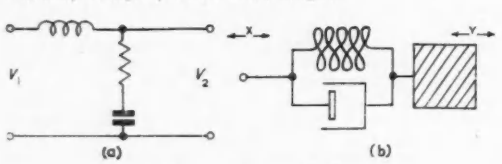
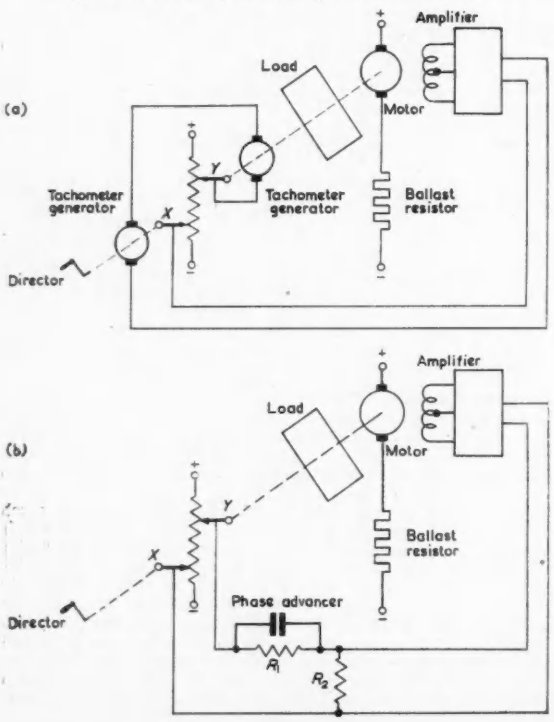


Fig. 18. Two passive second order systems

Fig. 19. Two active systems having second order responses



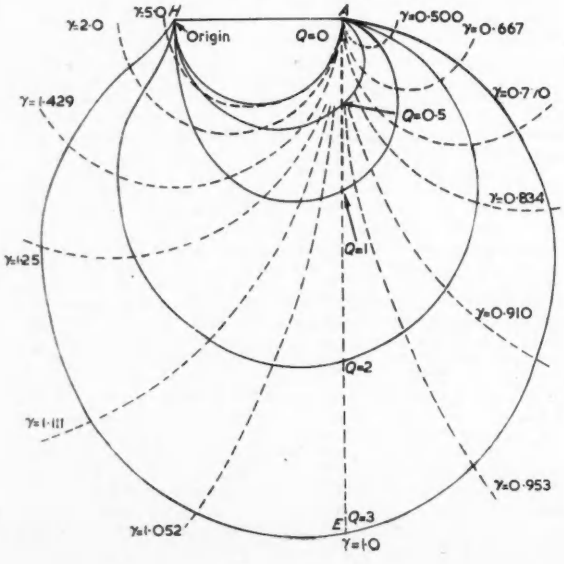
Set $T_0 = 1/\omega_0 = \sqrt{(LC)}$, and $Q = (1/R)\sqrt{(L/C)}$, and also let γ = relative frequency $= \omega/\omega_0 = \omega T_0$. Then:

$$V_2/V_1 = \frac{1 + j\gamma/Q}{1 + j\gamma/Q + j^2\gamma^2} = \frac{Q + j\gamma}{(1 - \gamma^2)Q + j\gamma} \quad \ldots\ldots (36)$$

The same expression serves to describe the response Y/X of the system of Fig. 18(b), if we set $T_0 = \sqrt{(M/K)}$ and $Q = (1/B)\sqrt{(MK)}$, and use has been made of this fact in assessing the influence of resilience between motor and load in servo-mechanisms[6].

Further examples of systems having similar responses are the two active systems of Fig. 19. A servo-mechanism damped in accordance with the relative velocity between the directing and responding members, as illustrated in Fig. 19(a), has a response as given by equation (36), provided that the time-lag in the amplifier is negligible. In practice, the measure of relative velocity is more frequently achieved as "error derivative" by use of a differentiating circuit as shown in Fig. 19(b). If $R_1 \gg R_2$, the response Y/X is described approximately by a function of the type in equation (36) except at the very highest frequencies.

Fig. 20. The cordiform loci $\dfrac{1 - j\gamma/Q}{1 - j\gamma/Q - j^2\gamma^2}$ for various values of Q



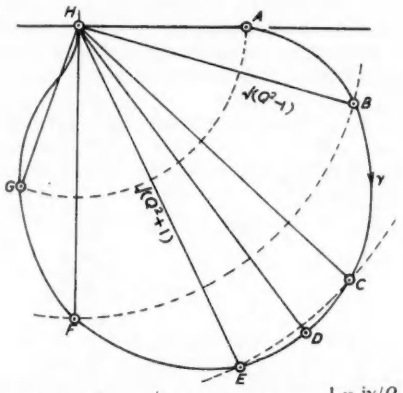


Fig. 21. Special points on the cordiform locus $\dfrac{1 - j\gamma/Q}{1 - j\gamma/Q - j^2\gamma^2}$

The Vector Loci for the Systems of Figs. 18 and 19

The behaviour of the response V_2/V_1, (or Y/X), may be represented by a vector plot of the function (36) as γ varies from zero to infinity. The loci are shown in Fig. 20 for values of Q equal to 0, 1, 2 and 3. These cordiform loci are the mirror images of the loci described in the previous article, the axis of reflection being the line $V_2/V_1 = \frac{1}{2}$.

The Q-value appropriate to any locus is easily determined by inspection, because when the response has unity real part, the quadrature response is Q times the zero-frequency response.

Further properties of the cordiform locus are illustrated in Fig. 21, which is drawn for the particular case $Q = 2$. For the responses of the systems described in the present article, the origin is placed at the "saddle" of the cordiform loci. For this position of the origin, the conditions for maximum magnitude of response are given by rather

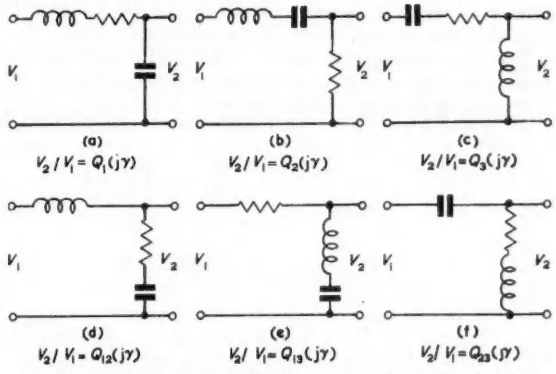


Fig. 22. Four-terminal networks with second order transfer functions

cumbrous expressions. If γ_m is the relative frequency and ϕ_m is the phase-lag for this condition, we have:

$$\gamma_m^2 = Q\sqrt{(Q^2 + 2)} - Q^2 \quad \ldots\ldots \quad (37(a))$$

$$|V_2/V_1|_{max}^2 = \frac{1}{1 + 2Q^3\sqrt{(Q^2+2)} - 2Q^2(Q^2+1)} \quad (37(b))$$

$$\cot \phi_m = Q(1 - \gamma^2)^2 - 1/Q \quad \ldots\ldots \quad (37(c))$$

There are other points on the locus which are described by much simpler expressions, and these are listed in Table 3. The data given in Table 2 of Part 2 are also applicable to this locus, provided that appropriate account is taken of the change of origin, etc.

Relationships Among the Second Order Response Functions

Fig. 22 depicts six four-terminal networks having transfer functions with second order denominators. The circuits (a), (b) and (d) have already received treatment in these articles. The circuits do not require completely individual

TABLE 3

Details of Special Points on the locus of $\dfrac{1 + j\,\gamma/Q}{1 + j\,\gamma/Q + j^2\gamma^2}$

POINT	γ^2	DEFINITION OF POINT	MAGNITUDE^2	$-\text{Tan}\ \theta$
A	0	Zero frequency point Response magnitude unity In-phase response unity	1	0
B	$1 - \dfrac{2}{Q^2}$	Response magnitude $\sqrt{(Q^2-1)}$	Q^2-1	$\dfrac{(Q^2-2)^{3/2}}{3Q^2-2}$
C	$\dfrac{Q^2}{Q^2+1}$	Response magnitude $\sqrt{(Q^2+1)}$	Q^2+1	$\dfrac{Q^2}{2\sqrt{(1+Q^2)}}$
D	See Eqn. 37(a)	Response magnitude maximum	See Eqn. 37(b)	See Eqn. 37(c)
E	1	Response magnitude $\sqrt{(Q^2+1)}$ In-phase response unity	Q^2+1	Q
F	$\dfrac{Q^2}{Q^2-1}$	Response magnitude $\sqrt{(Q^2-1)}$ Quadrature point	Q^2-1	∞
G	2	Response magnitude unity	1	$\dfrac{Q.2\sqrt{2}}{2-Q^2}$
H	∞	Infinite frequency point	0	0

treatment, as their transfer functions can all be depicted by either the circular locus or the cordiform locus.

For the investigation of the inter-relationships among these functions and loci, we define certain quadratic functions of any variable x as follows:

$$\mathbf{Q}_1(x) = \frac{1}{1 + x/Q + x^2} \quad \ldots\ldots\ldots (38(a))$$

$$\mathbf{Q}_2(x) = \frac{x/Q}{1 + x/Q + x^2} \quad \ldots\ldots\ldots (38(b))$$

$$\mathbf{Q}_3(x) = \frac{x^2}{1 + x/Q + x^2} \quad \ldots\ldots\ldots (38(c))$$

$$\mathbf{Q}_{12}(x) = \frac{1 + x/Q}{1 + x/Q + x^2} \quad \ldots\ldots\ldots (38(d))$$

$$\mathbf{Q}_{13}(x) = \frac{1 + x^2}{1 + x/Q + x^2} \quad \ldots\ldots\ldots (38(e))$$

$$\mathbf{Q}_{23}(x) = \frac{x/Q + x^2}{1 + x/Q + x^2} \quad \ldots\ldots\ldots (38(f))$$

where the subscripts in the function symbols denote the terms from the denominator that are used in the numerator. The following relationships are then apparent:

$$\mathbf{Q}_1(x) + \mathbf{Q}_2(x) + \mathbf{Q}_3(x) = \mathbf{Q}_{123}(x) = 1 \quad \ldots\ldots (39(a))$$

$$\mathbf{Q}_2(x) = \mathbf{Q}_2(1/x) \quad \ldots\ldots\ldots\ldots (39(b))$$

$$\mathbf{Q}_3(x) = \mathbf{Q}_1(1/x) \quad \ldots\ldots\ldots\ldots (39(c))$$

$$\mathbf{Q}_{12}(x) = 1 - \mathbf{Q}_1(1/x) \quad \ldots\ldots\ldots (39(d))$$

$$\mathbf{Q}_{13}(x) = 1 - \mathbf{Q}_2(x) \quad \ldots\ldots\ldots\ldots (39(e))$$

$$\mathbf{Q}_{23}(x) = 1 - \mathbf{Q}_1(x) \quad \ldots\ldots\ldots\ldots (39(f))$$

Hence, using equations (39(c)) to (39(f)), all the functions (38) can can be expressed in terms of the functions $\mathbf{Q}_1(x)$ and $\mathbf{Q}_2(x)$ alone. If we set $x = j\gamma = j\omega/\omega_0 = j\omega T_0$, the functions (38) become the transfer functions of the four-terminal networks of Fig. 22.

Geometrical Relationships Among the Second Order Response Loci

The response function for the circuit (e) of Fig. 22 is $\mathbf{Q}_{13}(j\gamma) = 1 - \mathbf{Q}_2(j\gamma)$. The corresponding vector locus can therefore be found by reversing all the vectors in the $\mathbf{Q}_2(j\gamma)$ locus that formed the subject of Part 2 and shifting the origin to the $\gamma = 1$ point, as shown in Fig. 23. The locus is of practical interest, as it also represents the transfer function of the well-known parallel-T null network.

The response function for the circuit (f) of Fig. 22 is $\mathbf{Q}_{23}(j\gamma) = 1 - \mathbf{Q}_1(j\gamma)$. The corresponding vector locus is

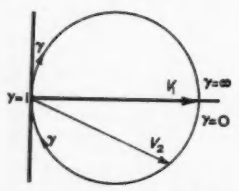


Fig. 23. The locus of $\mathbf{Q}_{13}(j\gamma)$

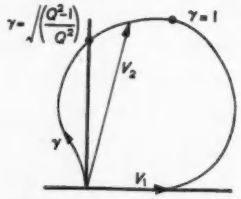


Fig. 24. The locus of $\mathbf{Q}_{23}(j\gamma)$

therefore found by reversing all the vectors of the $\mathbf{Q}_1(j\gamma)$ locus discussed in Part 3, and then shifting the origin from the infinite-frequency point to the zero-frequency point, as illustrated in Fig. 24.

The response function for the circuit (c) of Fig. 22 is $\mathbf{Q}_3(j\gamma) = \mathbf{Q}_1(1/j\gamma) = \mathbf{Q}(-j/\gamma)$. The corresponding vector locus is therefore found by reflecting the $\mathbf{Q}_1(j\gamma)$ locus in the real axis, and reversing the direction in which the locus is traversed for increasing γ, as shown in Fig. 25. This response is of interest in servomechanism theory, as it describes the feedback with respect to displacement derived from a tachometer generator feeding through a circuit such as that of Fig. 22(b) or its equivalent.

The response function for the circuit (d) of Fig. 22 is $\mathbf{Q}_{12}(j\gamma) = 1 - \mathbf{Q}_3(j\gamma)$, in accordance with equation (39(a)). The corresponding vector locus is therefore found by

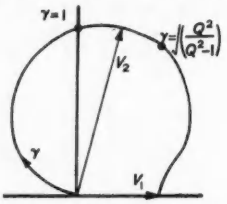


Fig. 25. The locus of $\mathbf{Q}_3(j\gamma)$

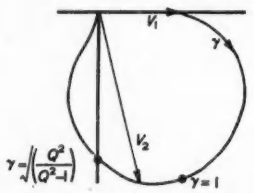


Fig. 26. The locus of $\mathbf{Q}_{12}(j\gamma)$

reversing all the vectors of the $\mathbf{Q}_3(j\gamma)$ locus of Fig. 25, and shifting the origin to the infinite-frequency point, as illustrated in Fig. 26. The locus has already been discussed in detail in connexion with Figs. 20 and 21.

General Conclusion

In this series of articles we have been concerned with first order responses, and with second order responses represented by functions of the general type:

$$\frac{k_1 + k_2 pT/Q + k_3 p^2T^2}{1 + pT/Q + p^2T^2}$$

Consideration has been confined to sinusoidal conditions, for which $pT = j\omega T = j\gamma$, and to specific responses in which the coefficients k are either zero or unity. Intermediate values of the coefficients are also possible, but all such responses can be expressed as a circular locus, as a cordiform locus in one of its aspects, or as a combination of these.

The majority of practical systems are of a higher order than the second, but a detailed study of the first and second order systems is worthwhile, because a response function of any order may in principle be expressed as a product of first and second order functions. The determination or combination of these component functions may be difficult in practice, but the mere knowledge that the possibility exists affords an insight into the types of behaviour that may be met.

It is sometimes not possible to express a second order response as the product of two real first order responses (i.e. when $Q > \frac{1}{2}$), and the phenomenon of resonance represents the possibility of a change in kind in passing from first order to second order systems. There are no further such changes in kind when we pass from second order to higher order systems. In higher order feedback systems a change of kind in the form of oscillatory instability is, of course, possible for certain changes in the system parameters, but this possibility is also represented in the second order system when Q becomes infinite or passes to negative values.

REFERENCE

6. Shaft Resilience in Servo-Mechanisms. *Engineering* (Dec. 10, 1954).

Corrigenda

1. In Part 2, the vector in Fig. 11 is drawn for $\rho = -0{\cdot}4$ and not for $\rho = 0{\cdot}4$.

2. In Part 3, in the text after equation (34), the reference should be to scales of $\rho = Q(\gamma - 1/\gamma)$ and $1/\rho$. In the penultimate paragraph, the reference should be to Fig. 15 and not to Fig. 17.

A D.C. Coupled Circuit Using Voltage Stabilizing Valves

By G. W. G. Court*, B.Sc., A.M.I.E.E., A.Inst.P.

The use of voltage stabilizing valves as a means of d.c. coupling between different voltage levels is often convenient in electronic circuits. In the circuit described, a chain of such valves has been used to transfer d.c. voltage variations from an initial reference level of 150V positive to a new reference level of 450V negative, with considerably less loss than that which would occur with a resistor chain.

CONSIDER a circuit (Fig. 1) in which a voltage generator e is at a d.c. potential E_o, and is connected in series with a voltage stabilizing valve V_R and a resistor R. The fundamental property of the valve is that, within a specified range of current through it, the voltage drop across it, E_v, is effectively constant. As examples, the VR105 maintains a voltage drop of about 105V, to within 1V, over a current range of 5 to 30mA, and the 85A2 which has an operating voltage spread from 83 to 87V, maintains the stabilized voltage to within 3V, for a current range of 1 to 10mA.

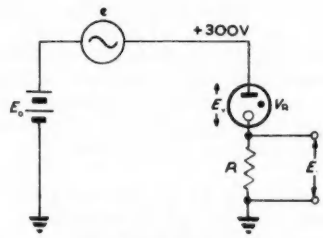


Fig. 1. Basic circuit

Assuming e is initially zero, the voltages across R is E_1, i.e. $(E_o - E_v)$. If e becomes a value e_1, then the voltage across R becomes $(E_o + e_1 - E_v)$, i.e. $(E_1 + e_1)$. Thus any change in e is reproduced at the cathode of V_R and the total variation in voltage, at the reference potential E_o, is transferred to a new reference potential E_1.

It is necessary to ensure that the current changes in V_R do not fall outside the specified limits for the valve, and if the changes are not small compared with the operating range, then the change in E_v must be considered. If in the case of a VR105, the current change, for a voltage change at E_o of e_1, is from 5 to 30mA, then V_R increases by 1V, and the transferred voltage change to the cathode of V_R would be $(e_1 - 1)$.

It is desirable therefore to make R as large as possible, consistent with maintaining the current in excess of the lower operating limit, to keep changes in E_v to a minimum. At the same time high values of R keep the static and dynamic loading on E_o and e respectively, to a minimum, which can be of importance when, as in the example given, the voltage source is the anode circuit of an amplifying valve.

Practical Circuit

In a microwave link it was found convenient to operate the receiver a.f.c. detector circuits and a subsequent d.c. amplifier valve, between 300V positive and earth potential. As a result the a.f.c. control voltage, obtained from the anode of the valve was at a mean d.c. potential of 150V (Fig. 2). The local oscillator of the receiver is a klystron

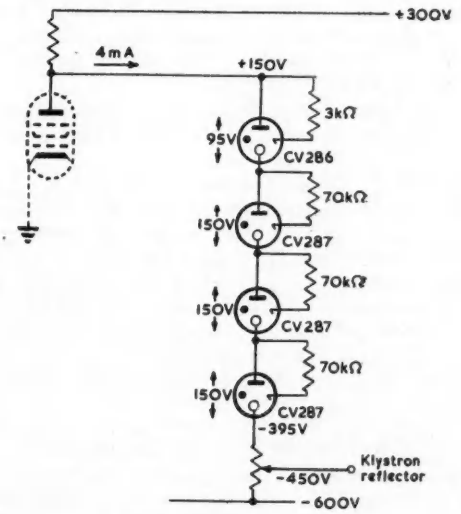


Fig. 2. Practical circuit

and it is highly desirable to operate the main body of it, and thus the resonator, at earth potential. This avoids insulation difficulties and possibility of electric shock during maintenance. The reflector potential is then about 450V negative, and the a.f.c. control voltage must be transferred to this reference potential, i.e. about 600V below the anode potential of the amplifier valve V_1.

* *Formerly Dominion Physical Laboratory, Department of Scientific and Industrial Research, New Zealand, now Civil Aviation Administration.*

If a resistor chain is used between V_1 and a negative potential of 600V, approximately 150/750, or 1/5 of the a.f.c. control voltage may be applied to the klystron reflector. However, if a chain of voltage stabilizing valves is used, as shown in Fig. 2, then practically the complete variation of V_1 anode voltage is realized at the top of the potentiometer connected to the end of the chain. The potentiometer is necessary to allow variation of the d.c. potential applied to the klystron reflector and thus provide the differences in reflector voltage required for different valves. It also provides compensation for slight differences in operating voltages of stabilizing valves. In the circuit given the reflector potential of -450V is obtained with the potentiometer suitably adjusted and about three-quarters of the a.f.c. control voltage, available at the top of the potentiometer, or the anode of V_1, is applied to the klystron reflector. This is a considerable increase on the fraction available by the use of a resistor chain.

The standing current through the chain is about 4mA and for a variation of ± 25V at V_1 anode, the current variation through the stabilizing valves is about $\pm 0{\cdot}5$mA. These values are well within the ratings of the valves used. Approximately ± 18V of a.f.c. control is available at the klystron reflector, which is more than adequate for the frequency control requirements.

This circuit has been in use for several months in the receiver of a continuously operated experimental microwave link, and has proved completely satisfactory. It is apparent that the result could have been achieved by other means, e.g. the resistor chain mentioned, in conjunction with a second amplifying stage. An extension of the requirements, however, to, say, a change of reference level of perhaps 1kV, and a change of control voltage to ± 100V, could considerably complicate such methods, whereas the use of voltage stabilizing valves would require only an extension of the chain.

Notes from North America

IRE National Symposium on Microwave Techniques

The National Symposium on Microwave Techniques will be held in Philadelphia on February 2 and 3, 1956. It is sponsored jointly by the Professional Group on Antennas and Propagation, the Professional Group on Microwave Theory and Techniques, and Philadelphia Section of the Institute of Radio Engineers.

A well balanced programme with technical papers and discussions on all phases of this subject is planned.

Colour Television in Hotel

The first substantial multiple installation of colour television receivers in hotel guest rooms has been completed at New York's Hotel Governor Clinton.

Fifty 21in RCA Victor colour sets have been placed in various rooms and suites as part of the regular furnishings. Seven hundred RCA Victor 21in black-and-white receivers also are in use and the hotel plans to increase the number until television has been installed in all 1 200 rooms.

RCA Victor Research Laboratories

The appointment of Dr. James Rennie Whitehead of McGill University to head the new RCA Victor Research Laboratories has recently been announced. Dr. Whitehead's work for Canada's largest electronic organization will be in the field of pure physics and electronic research not necessarily connected with the company's projects or developments.

From 1939 to 1951 Dr. Whitehead was associated with the British Government Telecommunications Research Establishment; he is a graduate of the University of Manchester and received his Ph.D. at the University of Cambridge.

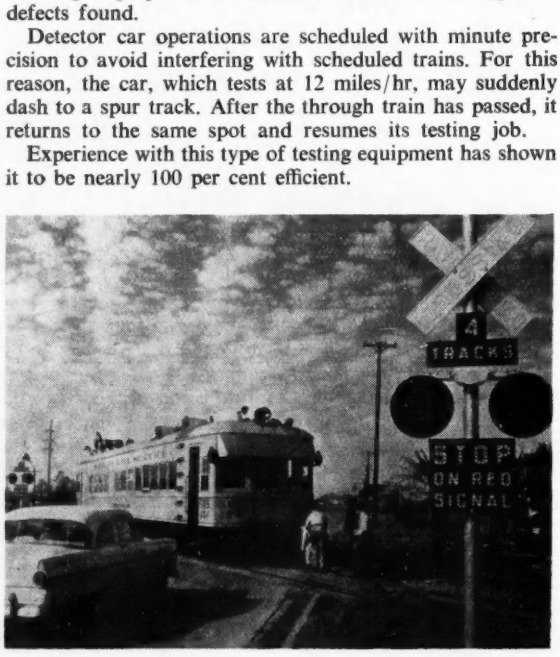
The Sperry Detector Car

Illustrated below is one of the Sperry Detector Cars which are used by Canadian National Railways for the routine testing of railway track. They are used to test rails and locate those which have developed internal defects and require replacement.

These test cars are manned by a crew of four specially trained operators. The testing process utilizes electric currents which are introduced into the rail and picked up again by recording devices. Any defect or flaw in the rail causes a voltage drop which is immediately sensed. Inked pens located in the operators' compartment record the voltage dips on a continuously moving paper tape, thereby assuring a perpetual and reliable record of the types of defects found.

Detector car operations are scheduled with minute precision to avoid interfering with scheduled trains. For this reason, the car, which tests at 12 miles/hr, may suddenly dash to a spur track. After the through train has passed, it returns to the same spot and resumes its testing job.

Experience with this type of testing equipment has shown it to be nearly 100 per cent efficient.



LETTERS TO THE EDITOR

(We do not hold ourselves responsible for the opinions of our correspondents)

A Waveform Synthesizer for Technical Training

DEAR SIR,—The article by Mr. T. S. Fox in the September issue is of considerable interest, as we have had an equipment of different design operating in the Electrical Engineering Department at Glasgow University since 1949.

Against our better judgment, we were convinced by our colleagues on the power side that a 50c/s fundamental frequency would greatly extend the usefulness of the equipment. This choice of frequency caused some difficulty in circuit design and, although the equipment has been used extensively for teaching demonstrations during the last six years, on relatively few occasions has the fundamental frequency been of significance.

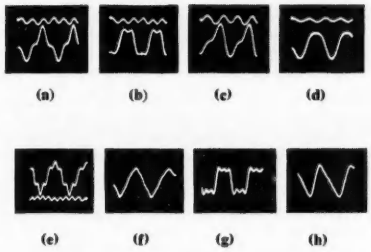


Fig. 3. (a) and (b) Fundamental+2nd harmonic; (c) and (d) fundamental+3rd harmonic; (e) fundamental+5th harmonic; (f) and (g) fundamental +3rd and 5th harmonics; (h) fundamental+2nd, 3rd and 5th harmonics

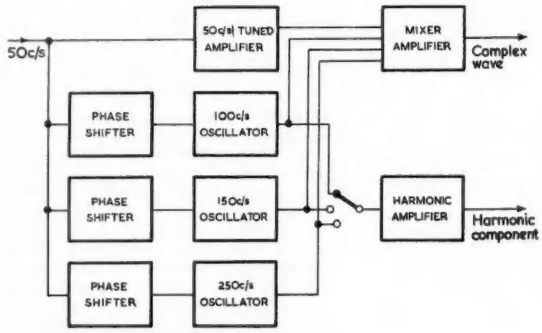


Fig. 1. Diagram of harmonic synthesizer

Fig. 1 shows the arrangement of the equipment in block schematic form. In order to keep the equipment reasonably modest in size and cost, only 2nd, 3rd and 5th harmonics are available. A typical oscillator with its synchronizing circuit is shown in Fig. 2. It will be seen that each harmonic is adjustable in phase and amplitude and that provision is made for viewing the complex wave and one harmonic simultaneously on a double-beam oscilloscope. Some typical traces are shown in Fig. 3.

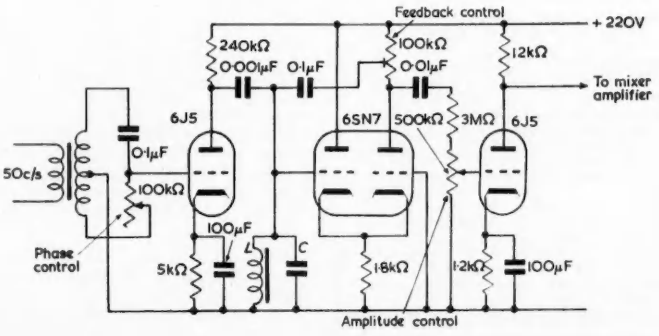
The credit for designing and constructing this equipment is largely due to Dr. T. K. Caughey, now Assistant Professor at California Institute of Technology.

An improved model has been considered and tested with one harmonic unit consisting of a simple inductor alternator with a resistance-capacitance filter to produce a good sinusoidal waveform. Phase shifting is performed mechanically and, where a fundamental frequency of 50c/s is required, it is thought that this method will prove the easiest and most economical.

Yours faithfully,

DOUGLAS S. GORDON,
Department of Electrical Engineering,
The University,
Glasgow, W.2.

Fig. 2. Typical harmonic generator



The Design of Hard-Valve Binary Counters

DEAR SIR,—While I do not wish to denigrate the value of the analysis carried out by Mr. Taub, I would suggest that by far the most important section of his paper is the conclusion.

Here we have the representative of a valve manufacturing company calling for "more detailed information" on valve characteristics.

The necessity for this is admirably illustrated in your September issue. On one page, 387, Mr. Taub assumes a tolerance of + 30 per cent − 50 per cent on average anode current. On another page (advertisement page 72) we are offered a "close tolerance twin triode" whose anode current is 8·5 ±4mA.

Yours faithfully,

E. L. HARRINGTON,
Henbury,
Bristol.

The author replies:

DEAR SIR,—I must thank Mr. Harrington for stressing the importance of tolerances yet again, but his illustration is not as admirable as would appear at first sight. The limits he quotes for the anode current of the type E90CC valve refer to a grid potential of −2·1V, whereas the limits quoted in the article refer to a very small grid potential (about −0·5V) as encountered in Eccles-Jordan circuits. On inquiry from the makers of the E90CC I find that under corresponding conditions (anode voltage = 150V and grid returned to cathode through 47kΩ) the specified anode current is 5·6 ± 0·6mA.

Regarding valves made by the company with which I was associated until recently, much information is given in their catalogue.

Yours faithfully,

D. M. TAUB,
London, S.W.1.
(Formerly Ericssons Telephones Ltd.)

Short News Items

Premiums for Technical Writing. Non-professional writers of technical articles dealing with radio and electronics, including specialized applications to any industry, and the editors responsible, are reminded in a leaflet issued by the Radio Industry Council of its premium award scheme, now in its fourth year and nearing the time for judging. Up to six premiums of 25 guineas each are offered yearly in respect of articles which, in the opinion of the Council's panel of judges, are likely to enhance the reputation of Great Britain in radio, television and electronics. The 19 awards so far made have happened to be mostly for articles in radio and electronic journals, but it is pointed out in the leaflet that many industries are increasingly using electronic methods of control and production and articles in the journals serving a wide variety of industries are eligible, provided they can be bought by the public on bookstalls or by subscription. Industries specifically concerned are the motor, aircraft, metal-working, woodworking, and food industries, with wide uses also in hospitals, clinics and research establishments. An innovation now announced is that one of the six premiums will be open for articles published in manufacturers' own journals with an overseas circulation, provided they also can be bought by the public. Details and further information may be obtained from the Secretary, Radio Industry Council, 59 Russell Square, London, W.C.1.

The new Chairman of the General Council of the British Standards Institution is Sir Herbert Manzoni, C.B.E., Engineer and Surveyor of the City of Birmingham since 1935. At the recent Annual General Meeting of B.S.I. Sir Roger Duncalfe, Chairman of British Glues and Chemicals Ltd, was re-elected President and Mr. John Ryan, Vice-Chairman of the Metal Box Co Ltd, was elected as Vice-President on completion of his three-year period of service as Chairman of the General Council. Another appointment was that of Sir Stanley Rawson, Vice-Chairman of John Brown & Co Ltd, who becomes Chairman of the B.S.I. Engineering Divisional Council.

Redifon Ltd announce that aircraft accompanying two South Pole expeditions will be guided over the icy wastes of Antarctica by Redifon radio beacons. The Hunting Air Survey group, now on its way to Graham Land, will operate a Redifon G.40, and the Commonwealth trans-Antarctic expedition will use two Redifon T.1918s. The T.1918 was first shown in public at this year's S.B.A.C. Exhibition at Farnborough.

Royal Society Medals. The following awards of medals have been made by the President and Council of the Royal Society.

The Copley Medal to Sir Ronald Fisher, F.R.S., Arthur Balfour Professor of Genetics in the University of Cambridge, for his distinguished contributions to developing the theory and application of statistics for making quantitative a vast field of biology.

The Davy Medal to Professor H. W. Melville, F.R.S., Mason Professor of Chemistry in the University of Birmingham, for his distinguished work in physical chemistry and in polymer reactions.

The Sylvester Medal to Professor E. C. Titchmarsh, F.R.S., Savilian Professor of Geometry in the University of Oxford, for his distinguished researches on the analytical theory of numbers, and other branches of pure mathematics.

The Hughes Medal to Professor H. S. W. Massey, F.R.S., Quain Professor of Physics at University College in the University of London, for his distinguished contributions to atomic and molecular physics, particularly in regard to collisions involving the production and recombination of ions.

Pye Ltd announce the formation of a French subsidiary company, to be known as Pye (France) S.A. The French company will be primarily engaged in the active introduction into the French market of the entire range of Pye Telecommunications products.

BINDING OF VOLUMES

Arrangements for the binding service are being continued this year, and the 1955 volume can be bound at an inclusive charge of £1.

Copies will be bound, complete with index and with advertising pages removed, in a good quality red cloth covered case blocked in gold on the spine.

Home and Overseas readers who wish to have their copies bound are asked to comply with the following instructions :—

(1) Tie the twelve issues (January to December, 1955) securely together before parcelling.

(2) Enclose a remittance for £1 and a gummed label bearing the sender's name and address.

(3) Enclose the copies, remittance and label in a closed parcel and address to :— The Circulation Dept. (E.E. Binding), 28, Essex Street, Strand, London, W.C.2.

(No other correspondence s necessary.)

* * * *

The following are also available from our Circulation Dept. :—

A limited number of Bound Volumes for 1954. Price, Two Guineas, post free.

Binding Cases for twelve issues. Price 5s., postage 6d.

The Index for Volume XXVII (1955) free.

The Radio and Electronic Component Manufacturers' Federation announces that its annual private exhibition will be held at Grosvenor House, London, W.1, from 10-12 April next, with, for the first time, a preview for overseas and other specially invited guests on the afternoon of 9 April. Application for admission to the preview should be made in advance to the Radio and Electronic Component Manufacturers' Federation, 21, Tothill Street, London, S.W.1.

The Mechanical Handling Exhibition and Convention will be held at Earls Court from 9-19 May 1956.

The Radio Industry Council announces that the 23rd annual National Radio and Television Exhibition (The Radio Show) will be held at Earls Court, London, from 22 August to 1 September 1956, with a preview for overseas and other special guests on 21 August.

The first power germanium rectifier for commercial service in Great Britain was manufactured by the British Thomson-Houston Co Ltd, to the order of Imperial Chemical Industries Ltd. The rectifier is rated 1 000kW, 255V, 3 920A and it will operate at continuous full load for long periods. It consists of two cubicles housing a series-parallel arrangement of air-cooled germanium rectifier cells connected to form a six-phase, full-wave bridge. The rectifier is supplied from an existing delta/diametric connected transformer which previously supplied a rotary convertor. The British Thomson-Houston Co is also supplying ten mechanical contact rectifiers, each rated 3 300/4 050kW, 220/270V, 15 000A, to Imperial Chemical Industries Ltd.

Powers-Samas Accounting Machines Ltd, a wholly owned subsidiary of Vickers Ltd, announce a further extension of their manufacturing capacity. At the beginning of this year Powers-Samas took over a large part of the Vickers-Armstrongs works at Dartford, Kent, and now a works of some 200 000 square feet at Southport, Lancashire, is being taken on a long lease from Brockhouse Engineering (Southport) Ltd for the production of punched card accounting machines and equipment. The demand for these machines both at home and abroad is increasing rapidly, stimulated by the latest electronic developments, and it is to help meet this increasing demand that the further premises are required.

RCA Photophone Ltd announce the move of their works and head offices from their previous location at Shepherds Bush to Sunbury-on-Thames, Middlesex, where an entirely new

modern factory and administrative centre has been built to meet the requirements of their expanding business. The address is RCA Photophone Ltd, Lincoln Way, Windmill Road, Sunbury-on-Thames, Middlesex. Telephone Sunbury-on-Thames 3101.

Metropolitan-Vickers Electrical Co Ltd have transferred the Industrial Process Control Engineering Department to the recently formed Electronics Department. Mr. R. H. Kelsall, formerly Assistant Chief Engineer, Industrial Process Control Department, is now Assistant Chief Engineer (Industrial Process Control), Electronics Department. This section is concerned with the industrial application of closed loop control systems in all its forms, including electronic and magnetic amplifiers; the use of computers and associated techniques in conjunction with control systems will also be within its field.

Hoechst Chemicals Ltd announce that the new improved type of polythene which is being manufactured by the Ziegler process is now in large-scale pilot plant production at the works of Farbwerke Hoechst AG., Western Germany. Bulk production is expected to commence at the end of this year, and development quantities for laboratory and factory scale tests are now available from Hoechst Chemicals Ltd, 27, Regent Street, London, S.W.1. New fields of application will be opened up by the advent of Hostalen due to its high softening point, great rigidity, and high resistance to solvents and chemicals.

The Fourth International Instruments and Measurements Conference and Exhibition will be held in Stockholm from 15-23 September 1956. The conference is organized by the Royal Academy of Engineering Sciences and the Swedish Association of Technical Physicists. Further information can be obtained from the Conference Secretary, Mr. Sven Malmstroom, P.O. Box 12035, Stockholm 12.

Marconi's Wireless Telegraph Co Ltd have been awarded a contract, worth more than £250 000, for the complete radar and communications equipment for two destroyers now under construction by Vickers-Armstrongs Ltd. These warships, which are being built for the Chilean Government, will be among the most modern of their class in the world.

Marconi's have also received an order for a complete new high-power broadcasting station, to be sited at Abu Ghraib, near Baghdad. The contract was placed by the Iraq Posts and Telegraphs Department.

The Plessey Co Ltd have released first details concerning the formation of a new company which is to control the establishment and development of a number of new Plessey enterprises in Great Britain. It is to be called The Plessey Development Co Ltd. The new company is being staffed with a number of senior engineering and production personnel specially engaged for the purpose, together with certain Plessey personnel who have been seconded to the new organization. Directors of The Plessey Development Co Ltd are Mr. A. G. Clark, who is Chairman and Managing Director, and Messrs. E. J. Earnshaw and A. E. Underwood.

Ferranti Ltd have opened a new Research and Development Establishment of their Aircraft Equipment Department at "Westwick", Bagshot Road, Bracknell, Berks. The department will primarily be concerned with the development of new systems and components for aircraft electrical equipment and instrumentation with particular reference to gyroscopic and associated navigation systems. The Chief Engineer is Mr. W. A. Mallinson and the Chief Research Engineer is Mr. J. W. Barnes, late of the R.A.E., Farnborough.

The Lord President of the Council has, with the concurrence of the Chancellor of the Exchequer, appointed Mr. W. Strath, C.B., at present serving as a Third Secretary in H.M. Treasury, to be a full-time member of the Atomic Energy Authority. He has also appointed as part-time members Sir Rowland Smith, Chairman of the Ford Motor Co, and Mr. C. F. Kearton, a Director of Courtaulds Ltd.

Edwards High Vacuum Ltd in the drive for exports are using helicopters to ferry overseas visitors from London Airport to their factory in Crawley New Town, thirty miles away. The flights are provided by Helicopter Services Ltd.

E. K. Cole Ltd have developed a television set to be specially built into a car, and this made its debut at the recent Motor Show at Earls Court.

Cable and Wireless Ltd announce that a new radio telephone service has been opened between Bahrein, Persian Gulf, and Karachi, Pakistan. The service was inaugurated by Shaikh Isa Bin Sulman, eldest son of the Ruler of Bahrein, who spoke with the Postmaster-General in Karachi.

The General Electric Co Ltd have supplied an automatic telephone exchange to Messrs. Chr. Salvesen & Co for installation at their Whaling Station in South Georgia, one of the Falkland Islands Dependencies on the fringes of Antarctica. When installed, the exchange will be the most southerly automatic exchange operating in the world. The components are suitably protected against the extreme climatic conditions which will be encountered by the equipment which must pass through the tropics during its journey to the Antarctic. The equipment is being shipped on the whaling factory ship "Southern Venturer".

"Automation" Meeting and Exhibition. The President of the French Association of Electronic Engineers has announced a meeting and exhibition on this subject to be held in Paris from 18 to 24 June 1956. Details may be obtained from Secretariat du Colloque sur l'Automatique, Chaire de Mecanique, Conservatoire National des Arts et Metiers, 292 rue Saint-Martin, Paris.

Kingston Technical College, Department of Engineering, are to hold Post-Graduate evening courses on Pulse Techniques and Aircraft Electrical Equipment, commencing in the New Year. The former course will start on 17 January and the latter on 12 January. Further details and lecture programmes are obtainable from the Head of the Engineering Department, Kingston Technical College, Fassett Road, Kingston-upon-Thames, Surrey.

Granada TV Network Ltd announce the appointment of Mr. P. J. Peate as Assistant Telecine/Telerecording Engineer. Mr. Peate was previously with the Telerecording Department of the BBC at Lime Grove Studios.

Marconi International Marine Communication Co Ltd have opened new premises at Marconi House, Melbourne Street, Newcastle-upon-Tyne. These premises supersede the old in Pudding Chare, off Collingwood Street, which have housed the Newcastle depot since 1929. Prior to that date the depot had been in Royal Arcade and in Milburn House, Dean Street, where it was first established in 1913.

The Automatic Coil Winder and Electrical Equipment Co Ltd announce a new trading arrangement with Messrs. Blume & Redecker, of Hanover. The effect of the agreement is that the Automatic Coil Winder & Electrical Equipment Co Ltd have taken over sales of the German manufacturer's laminating, wire stripping and coil winding equipment for the United Kingdom and Commonwealth markets, as well as for China, Japan, Argentina, Russia and Russian satellite countries. The English company will continue also to market the range of "Douglas" and "Macadie" coil winders of their own manufacture.

The Society of Industrial Radiology and Allied Methods of Non-Destructive Testing, which was founded at the close of last year, and now has a membership of over 200, is the first professional body in this country endeavouring to co-ordinate all specialists employed in the various methods of non-destructive testing. Its chief concern is to establish and maintain a high standard of technical practice and to facilitate the exchange of information and ideas on matters concerning these rapidly expanding methods of inspection. With these objects in view, a programme of monthly meetings has been arranged by branches of the Society in London, Birmingham, Sheffield and Glasgow. Particulars may be obtained from the Honorary Secretary, D. N. Laurie, 2 Tomswood Terrace, Barkingside, Essex.

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BOOK REVIEWS

Electromagnetic Principles of the Dynamo

By E. B. Moullin. 367 pp. 70 figs. Demy 8vo. Oxford University Press. 1955. Price 50s.

THIS very useful book is intended for elementary teaching although it contains some advanced sections.

The first chapter is devoted to basic principles, the general form of the machine is described and many technical terms are defined. Sections are included on torque, e.m.f. of a dynamo, windings, the commutator and the homopolar machine. The book is intended to be read in conjunction with the author's "The Principles of Electromagnetism" to which there are over eighty cross-references, nearly fifty of these being in the first three chapters. Although such cross-references avoid digressions on the theory of magnetism they are disturbing and should be unnecessary in a book costing 50s. On page 1 the reader is told that the references are to the 2nd edition of the previous book but on pages 294, 302 and 311 examples are referred to at the end of the 3rd edition. There are no examples at the end of the 2nd edition.

The second chapter deals with the estimation of ampere-turns on the poles and the method given is illustrated by a numerical example. A valuable feature of the book is that many such examples are worked out in the text and there are 80 questions with solutions at the end. It is surprising to find that the M.K.S. system of units is not used.

Chapter III gives an account of the magnetic effect of the armature current. It includes notes on interpoles and compensating windings and gives a further discussion on torque. Chapter IV covers methods of excitation, load characteristics of generators, generators in parallel and characteristics of motors.

Efficiency and energy losses are discussed in Chapter V. Methods of separating losses into their various components and efficiency testing are given. Some errors were observed here, the most serious being the statement on page 141 that all insulating materials available at present and usable in a machine soften or deteriorate permanently at about 200° F. Chapter VI is allocated to commutation. Information on boosters, balances and the Rosenberg and other special machines is presented in Chapter VII.

It is debatable whether the last supplementary chapter, occupying sixty-one pages and giving much of the electromagnetic treatment needed for a.c. machines, should have been included. It seems that the real reason for putting it in was that it would help the author with his teaching. In fact the reader is warned that he need not study this chapter if he is disinclined to do so. Much of the material given here, however, is not far removed from the main theme.

The book is written in an attractive manner and is clearly illustrated with many diagrams although a few of these are rather small (e.g. Figs. 4-6(a), 4-9(a), 5-14). It will be of great value to engineering students. It is rather expensive but a student who spends 50s. on its purchase will never regret having done so.

F. A. BENSON.

Networks, Lines, and Fields

By J. D. Ryder. 93 pp. 261 figs. Demy 8vo. 2nd Edition. Prentice-Hall, Inc., New York. Bailey Bros. and Swinfen, Ltd., London. 1955. Price 80s.

THIS is the second edition of a book in the Prentice-Hall Electrical Engineering Series which was published initially in 1949. The purpose of the book is to provide an introduction to quantitative communication engineering. According to the preface, the author has attempted to develop the subject of communication networks and lines by describing their performance in terms of certain measured or defined parameters. The study of fields is facilitated by the use of the analogous transmission line. This new edition is somewhat larger than the original and contains a number of new features.

The application of matrices to the solution of steady-state circuit problems has been extended but, in this reviewer's opinion, the book would have benefited if matrices had been omitted altogether. The introduction to the subject in the first chapter is superficial and not particularly well done. The explanation of matrix multiplication contains a mistake which will confuse the reader who attempts the multiplication of two non-square matrices. On page 44 an example is given of the inverse of a second order matrix which is, in fact, the determinant of the transpose of the inverse! This error would seriously impede the progress of the student were it not that in the following section, which purports to explain the use of matrices in circuit calculations, the method shown is not matrix analysis but determinantal analysis; indeed, matrix inversion is employed nowhere in the book. The chapter continues with a vague mixture of general passive network matrix analysis and Strecker-Feldtkeller passive fourpole matrix analysis but it appears to be the latter with which the author is really concerned. The treatment of fourpole interconnexion by the Strecker-Feldtkeller process leaves much to be desired. In the course of the discussion of this topic, reference is made to matrices introduced earlier which are not those of fourpoles and no mention is made of the restrictions under which certain interconnexions are permissible.

Chapter II has been extended to include Foster's reactance theorem and further space has been given to the use

of the Smith chart in transmission line theory in Chapter VII. Three new chapters have been added to increase the scope of the book. These deal with the determination of the parameters of polyphase lines, power transmission lines, and elementary aerial theory. The vector analysis approach has now been adopted in the treatment of time-dependent fields and electromagnetic radiation. Vector theory is developed as it is required and no prior knowledge of the subject is expected of the reader.

The author's aim to demonstrate the unity between the theory of discrete and distributed parameter systems could have been accomplished with greater elegance had the matrix theory of fourpoles been properly and earnestly developed at the beginning of the book. An opportunity to exploit modern matrix techniques has been missed; the papers of Professor L. A. Pipes indicate the possibilities in this direction. However, the book serves the author's purpose and has a place among the many text-books now available on the transmission of electric energy through networks, along lines, through guides, and into space. The book is well printed and attractively bound.

S. R. DEARDS.

Radio Astronomy

By J. L. Pawsey and R. N. Bracewell. 354 pp. 150 figs. Demy 8vo. Oxford University Press. 1955. Price 55s.

THE subject of this book is the study of astronomy by means of radio waves rather than by light. It is now nearly a quarter of a century since Karl Jansky showed that radio waves are reaching the earth from outer space, and the time is ripe for this authoritative text book on the new branch of science which was founded on his work. The authors of the book are well-known members of the Radiophysics Laboratory in Sydney where so much of the original work on radio-astronomy has been done. They have thus been able to draw on a considerable body of first hand experience and this, coupled with an unusually clear style of writing, makes the book both a valuable contribution to the subject and a great pleasure to read.

About one-fifth of the book is devoted to the techniques of radio-astronomy. There are also separate chapters on the theory of propagation in ionized gases, the effects of the earth's atmosphere on extra-terrestrial radio waves, and some aspects of astrophysics relevant to radio-astronomy. The authors claim in the preface that "the book must cater for those who know astronomy, but not radio and also for those who know radio but little astronomy, and so we have tried to make it readable by anyone with a background of physics". They must be congratulated on the success of their efforts; the treatment of the subject throughout places a welcome emphasis on the essential physical processes which are involved, and there are few radio engineers who would not learn something about their own subject from reading these chapters.

The remainder of the book gives an account of the sun, the moon, meteors and the universe beyond the solar system as "seen" by radio waves. There is also a short chapter devoted to radar echoes from the moon and to the possibility of radar echoes from the sun and planets. One of the principal difficulties in writing a text-book on a rapidly expanding subject is that significant changes in the relative importance of various topics may occur between writing and publication. The present book has not escaped this difficulty and in the light of recent work, particularly on the study of the Galaxy by the 21cm. radiation from neutral hydrogen, it is clear that too little space has been given to a discussion of the radio stars and the Galaxy in comparison with that devoted to the sun. Nevertheless the chapters on the sun are themselves excellent and will be given a particular welcome by radio-astronomers.

In conclusion I recommend this book, which is illustrated with a number of striking photographs, to all whose interests embrace astronomy or radiophysics, and to all scientists and engineers who wish to explore a fascinating new subject with reliable guides.

R. HANBURY BROWN.

An Introduction To Process Control System Design

By A. J. Young. 378 pp., 60 figs. Demy 8vo. Longmans, Green & Co. Ltd. 1955. Price 42s.

THE author of this book examines the basic principles in quantitative terms, with emphasis on dynamic characteristics, using only the simplest mathematics. Formulae are given, and the data required in practice are presented in graphical form to facilitate their interpretation and use.

The beginner is led, by logical stages, to an understanding of the principles governing the operation of control systems. At the same time, the experienced engineer will find much that is of interest to him.

The author, elected President of the Society of Instrument Technology in 1954, has had long experience in the field as Head of the Central Instrument Laboratory of Imperial Chemical Industries.

Proceedings Of The Symposium On Printed Circuits

122 pp., 40 figs. Demy 4to. Engineering Publishers, New York. 1955. Price $5·00.

THIS book contains the full versions of the technical papers presented at the 1955 Symposium on Printed Circuits sponsored by the Engineering Department of the Radio-Electronics-Television Manufacturers' Association with the participation of the Professional Group on Production Techniques of the Institute of Radio Engineers. Also included are the pertinent questions and answers of the discussion periods following the presentation of each paper. The subject matter covers all of the methods of printed circuitry currently in commercial use.

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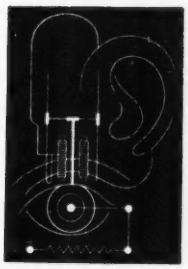

Books on radio theory, practice and maintenance for the beginner and books on new developments in circuit design, new components, methods of application, and the established text books can be obtained through your local Smith's shop or bookstall. Books not in stock at the branch can be quickly obtained from Head Office.

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ELECTRONIC EQUIPMENT

A description, compiled from information supplied by the manufacturers, of new components, accessories and test instruments.

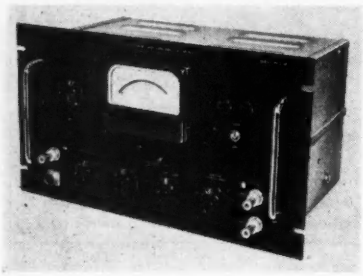
Wideband Amplifier and Discriminator

(Illustrated below)

THE type 652 is a rugged, precision linear amplifier, with built-in metered voltage discriminator, for use with scintillation and other nucleonic counters. Regulated h.t. and l.t. power supplies are provided for operating an external cathode-follower.

The amplifier provides a gain between 40dB and 80dB, i.e. (100 to 10 000) in 2dB steps. With a minimum rise-time and maximum fall-time, the gain is 3dB down at 1·7kc/s and 5Mc/s. Independently selectable rise- and fall-time constants provided: 0·03 to 10μsec and 0.1 to 100 μsec respectively.

This amplifier, with the "I.D.L." scin-



tillation counter head, type 653, fitted with the appropriate end cap and scintillator, forms a versatile basic unit to meet a wide range of scintillation counting techniques, including beta and gamma ray spectrometry, diagnostic and therapeutic purposes in hospitals, measurements on solid or liquid samples in lead castles, and general routine investigations.

The pulse from the amplifier and discriminator unit may be fed direct to a standard "I.D.L." scaler or ratemeter, or through the "I.D.L." single channel pulse analyzer, type 672, for the scanning of pulse spectra.

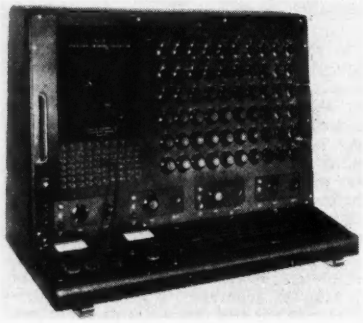
Isotope Developments Ltd,
Beenham Grange,
Aldermaston Wharf,
Nr. Reading,
Berkshire.

Fluid Network Analyser

(Illustrated above right)

THIS instrument has been designed to assist in the solution of non-linear network problems which are tedious to solve by the ordinary methods of mathematical analysis.

Such problems arise in the flow of oil, water, gas or air in distribution or ventilation systems. The instrument may be used for the solution of flow problems in fluids to which a general law of the type $P = CQn$ applies, where P = Pressure, Q = Rate of Flow, C = Constant of fluid resistance, n = Index of flow. It is a development of a laboratory instru-



ment devised at Nottingham University as a result of research sponsored by the National Coal Board.

The principle on which the instrument is based is the establishment of a network of linear electrical resistors identical in pattern to the system to be studied. This enables Kirchoff's relationships to be continuously satisfied while the electrical resistances are successively adjusted until the electrical currents flowing in the resistors correspond to the fluid flows in the system.

The currents and pressure drops around the network are read on calibrated meters connected into circuit by means of jacks. The resistors on the instrument, which simulate branches of the system, are brought out to a connexion panel, where they may be connected into a number of junctions. Power packs stabilized against mains supply changes are provided to simulate sources of pressure, e.g. fans, pumps.

Where the system requires it, a separate panel is used incorporating a number of units which simulate loads taking constant flows regardless of supply pressure. These can be connected into circuit in the same way as the resistors representing branches or sections of main.

Nash & Thompson Ltd,
Oakcroft Road,
Chessington,
Surrey.

New Valves

THE Mullard series of noval based valves for use in a.c. mains-operated f.m/a.m receivers has now been supplemented by an equivalent range having a common heater current rating of 100mA. These valves enable the design of efficient f.m/a.m receivers for operation from both a.c. and d.c. mains.

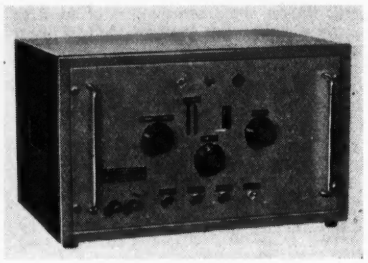
This new range comprises the UCC85 r.f. double triode, the UCH81 triode-heptode, the high-slope variable-mu pentode type UF89, the UABC80 triple-diode-triode, and the UL84 high-slope 12W output pentode. The associated half-wave rectifier is the UY85.

The PCL82 is a noval-based triode-pentode with separate cathodes. It is suitable for use in the frame time-base circuits of transformerless television receivers employing 90° scanning tubes.

The triode section then functions as a blocking oscillator and the pentode section as a frame output valve.

The PCL82 has a 16V, 300mA heater, and will operate satisfactorily from a high tension line of 170V. The triode section has an amplification factor of 70 and a mutual conductance of 2·2mA/V. The pentode section has a maximum rated anode dissipation of 7W, and a mutual conductance of 7·5mA/V.

Mullard Ltd,
Century House,
Shaftesbury Avenue,
London, W.C.2.



Sweep Frequency Oscillator

(Illustrated above)

THE "Rivlin" sweep frequency oscillator has been designed basically to meet the needs of valve manufacturers who require to test valves under vibration conditions. It is, however, suitable for vibration investigation work generally.

Frequency range of the instrument is 20c/s to 3kc/s, but this can be varied to suit individual requirements. There is provision for either motor drive or manual control. The band to be swept can be adjusted by means of setting the upper and lower limit dials. The output is constant with 3 per cent over the whole range, and the maximum output is 0·1V into 600Ω.

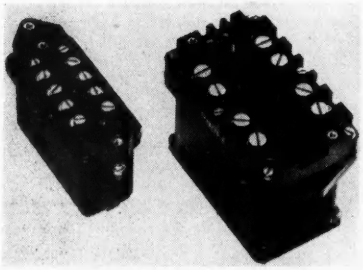
The motor drive is operated by push buttons, i.e. stop, start and reverse. There is a continuous cycling switch so that either one sweep can be performed and then the drive is stopped or continuous sweeping can be obtained.

Rivlin Instruments Ltd,
7a, Maitland Park Villas,
London, N.W.3.

Sealed Relays

(Illustrated above right)

THESE sealed relays are a development of the Pullin S-type range and while using basically the same mechanism as the existing types and being produced in the same ratings, incorporate a much improved sealing method together with a significant reduction in weight and bulk. The main features of the new sealed type are a neoprene gasket, and an



entirely new true wiping action, giving 0·015in sliding movement of the contact surfaces, on which a contact pressure of 35g is exerted. The standard contact material on the normal S-type relays is "Elkonite", a nickel-silver alloy, with precious metal (such as platinum-gold-silver) as an alternative if required. Tests carried out on prototypes have already established that they withstand forces of up to 20*g*, and vibrations of 0·003in amplitude at 250 to 8 000c/s.

In the above illustration the sealed relay (left) is compared with the weatherproof S2 type.

Measuring Instruments (Pullin) Ltd,
Electrin Works,
Winchester Street,
Acton,
London, W.3.

"One-Shot" Cells

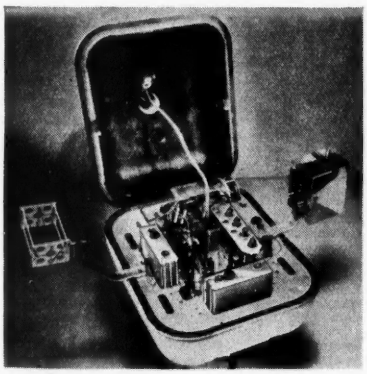
(Illustrated below)

A NEW cell that operates efficiently without electrolyte spillage at the greatly reduced atmospheric pressures encountered in stratospheric flight has been evolved by Chloride Batteries Ltd.

It is the Exide Z2H11, an unspillable, "one-shot", primary cell developed in conjunction with the Ministry of Supply. Used in batteries of three to provide about 6·75V, it will power the metering and telecommunication equipment of the radar sonde mark 3 meteorological balloon. Of special lightweight design, the cells are primed with electrolyte shortly before the balloon take-off.

Primed cells can stand idle from 15 minutes to seven hours yet still discharge through a fixed resistor of 0·88Ω for a period of not less than two hours to a final minimum voltage of 2·25V. This discharge is in an ambient temperature of approximately 70°F and with the atmospheric pressure reduced progressively during discharge to simulate flight conditions.

In the illustration three of these cells are shown fitted in a mark 3 radar sonde.



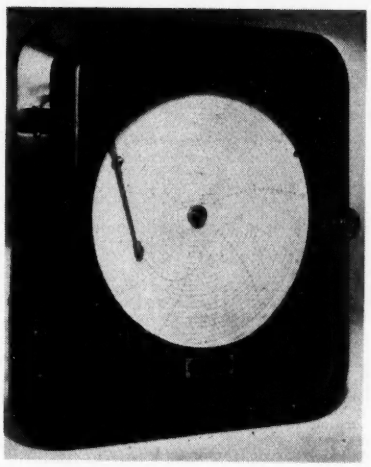
Chloride Batteries Ltd,
Clifton Junction,
Swinton,
Manchester.

Servograph Recorder

(Illustrated below)

FIELDEN Electronics have recently introduced a high performance-low priced recorder known as the Servograph mark II. This extremely versatile instrument is suitable for direct operation from pH meters, CO_2 indicators, smoke density meters, beta gauges, tachometers and many other uses as well as a recording voltmeter and ammeter.

The instrument operates directly from



micro current sources. It can replace any moving-coil indicating meter without imposing any additional load on the source of measurement or involving any loss of accuracy.

The instrument is manufactured in three different models suitable for either laboratory or plant use

Fielden Electronics Ltd,
Paston Road,
Wythenshawe,
Manchester, 22.

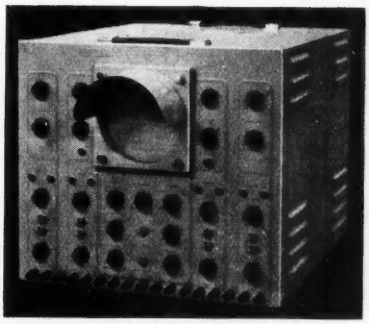
Oscilloscopes

(Illustrated above right)

TWO new general purpose oscilloscopes have been recently developed by Southern Instruments incorporating flat-faced 6in cathode-ray tubes by 20th Century Electronics Ltd. The M972 is a dual gun type and the M974 four-gun. The gun assemblies are entirely separate, enabling full use to be made of independent beam and plate controls without interaction.

Separate identical Y amplifiers for each beam make possible the direct comparison of waveforms.

The gain of each Y amplifier is continuously variable from 80 to 1 500 over a bandwidth from d.c. to 100kc/s. *RC* coupling can be provided by switch



selection and there is a frequency compensated 10 :1 input attenuator.

The M972 has separate identical X amplifiers flat from d.c. to 50kc/s ±1dB with unbalanced input, and the M974 two X amplifiers with equalizing pre-set controls to give exact X axis alignment on all four beams.

The time-base is continuously variable from 2c/s to 30kc/s and can be synchronized internally or from an external signal as low as 100mV. In addition, provision is made for synchronization from contacts on a machine or vibratory device, and for beam triggering from the timing contacts on the company's universal camera.

Time marking by brightening or blanking pulses may be applied by Z axis modulation.

The equipment is designed to a high standard throughout, particular attention having been paid to ease of maintenance.

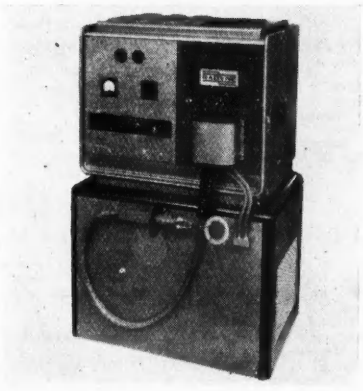
Southern Instruments Ltd,
Frimley Road,
Camberley,
Surrey.

Bench Type Induction Heater

(Illustrated below)

THIS is a compact r.f. induction heater suitable for bench mounting. Two types are available with outputs of 1kW and 3kW respectively. The output is variable over a range of 20:1. Provision is made for the incorporation of a process timer, two work stations and remote operation as optional extras.

Radio Heaters Ltd,
Wokingham,
Berkshire.



Meetings this Month

THE BRITISH INSTITUTION OF RADIO ENGINEERS

Date: 14 December. Time: 6 30 p.m.
Held at: The London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.
Lecture: The Remote Presentation of Radar Information.
By: G. J. Dixon and H. H. Thomas.

North-Western Section

Date: 1 December. Time: 6.30 p.m.
Held at: The Reynolds Hall, College of Technology, Sackville Street, Manchester.
Lecture: The Latest Developments in Computer Design.
By: J. J. Moore.

Merseyside Section

Date: 7 December. Time: 7 p.m.
Held at: The Council Room, Chamber of Commerce, Old Hall Street, Liverpool 3.
Lecture: The Development of a Design for an Angle Modulation Radio Link.
By: H. C. Spencer.

South Wales Section

Date: 7 December. Time: 6.30 p.m.
Held at: Llandaff Technical College, Western Avenue, Cardiff.
Discussion: The Training of Radio Engineers.
Opened by: W. J. Thomas, H. Roberts and A. J. Kenward.

Scottish Section

Date: 8 December. Time: 7 p.m.
Held at: The Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow.
Lecture: Automatic Control of Machine Tools.
By: H. Ogden.

West Midlands Section

Date: 14 December. Time: 7.15 p.m.
Held at: Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton.
Lecture: Television Aerial Design with Emphasis on Band III Problems.
By: I. A. Davidson.

North-Eastern Section

Date: 14 December. Time: 6 p.m.
Held at: The Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle-upon-Tyne.
Lecture: The Metal Cone Loudspeaker.
By: W. I. Heath.

THE BRITISH KINEMATOGRAPH SOCIETY

Date: 7 December. Time: 7.15 p.m.
Held at: The Gaumont-British Theatre, Film House, Wardour Street, London, W.1.
Lecture: Handling the new Presentation Techniques.
By: R. E. Pulman.

THE INSTITUTE OF PHYSICS

Manchester and District Branch

Date: 9 December. Time: 6.45 p.m.
Held at: The Bragg Building, University of Manchester.
Lecture: The History and Applications of Computers.
By: B. V. Bowden.

THE INSTITUTION OF ELECTRICAL ENGINEERS

All London meetings, unless otherwise stated, will be held at the Institution, commencing at 5.30 p.m.

Date: 1 December.
Lecture: TRIDAC A large Analogue Computing Machine.
By: F. R. J. Spearman, J. J. Gait and A. V. Hemingway.

Informal Meeting

Date: 5 December.
Discussion: Private Generation from the Point of view of the User.
Opened by: A. N. Irens.

Radio and Telecommunication Section

Date: 7 December.
Lecture: Some Half-Tone Storage Tubes.
By: R. S. Webley, H. G. Lubczynski and J. A. Lodge.
Date: 12 December.
Informal Lecture: The Television Studio as seen by the Producer.
By: Alvin Rakoff.

East Anglian Sub-Centre

Date: 15 December. Time: 7.30 p.m.
Held at: The Assembly House, Norwich.
Lecture: Industrial Application of Radio-Active Isotopes.
By: S. Jefferson.

Mersey and North Wales Centre

Date: 5 December. Time: 6.30 p.m.
Held at: The Electrical Engineering Department, Brownlow Hill, Liverpool.
Lecture: Transistor Power Amplifiers.
By: R. A. Hilbourne.

North-Eastern Radio and Measurements Group

Date: 5 December. Time: 6.15 p.m.
Held at: King's College, Newcastle upon Tyne.
Lecture: Artificial Reverberation.
By: P. E. Axon, C. L. S. Gilford and D. E. L. Shorter.

North-Western Centre

Date: 6 December. Time: 6.15 p.m.
Held at: The Engineers' Club, Albert Square, Manchester.
Lecture: TRIDAC A Large Analogue Computing Machine.
By: F. J. R. Spearman, J. J. Gait and A. V. Hemingway.

South-East Scotland Sub-Centre

Date: 20 December. Time: 7 p.m.
Held at: The Carlton Hotel, North Bridge, Edinburgh.
Lecture: High-Speed Electronic Analogue Computing Techniques.
By: D. M. MacKay.

South Midland Centre

Date: 5 December. Time: 6 p.m.
Held at: The James Watt Memorial Institute, Great Charles Street, Birmingham.
Lecture: Underwater Echo-Ranging.
By: D. G. Tucker.
(Joint Meeting with the Radio and Telecommunication, and the Supply and Utilization Groups and the Birmingham Centre of the Institution of Post Office Electrical Engineers.)

Rugby Sub-Centre

Date: 14 December. Time: 6 p.m.
Held at: The Rugby College of Technology and Arts.
Lecture: Atomic Power Stations.
By: D. F. Welch.

Southern Centre

Date: 14 December. Time: 6.30 p.m.
Held at: R.A.E. Technical College, Farnborough.
Lecture: The Use of Transistors in Computer Type Circuits.
By: G. B. B. Chaplain.

Western Centre

Date: 1 December. Time: 6.30 p.m.
Held at: Sofia Gardens Pavilion, Cardiff.
Faraday Lecture: Coal Mining Electrically.
By: B. L. Metcalf.

South-Western Sub-Centre

Date: 1 December. Time 3 p.m.
Held at: The Electricity Showrooms, New George Street, Plymouth.
Lecture: Transistors.
By: R. A. L. Cole.

West Wales (Swansea) Sub-Centre

Date: 8 December. Time: 6 p.m.
Held at: The Conference Room, South Wales Electricity Board Showrooms, The Kingsway, Swansea.
Lecture: Thermionic Valves of Improved Quality for Government and Industrial Purposes.
By: E. G. Rowe, P. Welch and W. W. Wright.

RADIO SOCIETY OF GREAT BRITAIN

Date: 16 December. Time: 6.30 p.m.
Held at: The Institution of Electrical Engineers, Savoy Place, London, W.C.2.
Annual General Meeting.

SOCIETY OF INSTRUMENT TECHNOLOGY

Date: 6 December. Time: 7 p.m.
Held at: Manson House, Portland Place, London, W.1.
Lecture: Planning a Servo-mechanisms Laboratory for Instructional Purposes.
By: E. B. Pearson.

THE TELEVISION SOCIETY

Date: 9 December. Time: 7 p.m.
Held at: The Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2.
Lecture: The Secondary Emission Valve and its Applications.
By: A. H. Atherton.

PUBLICATIONS RECEIVED

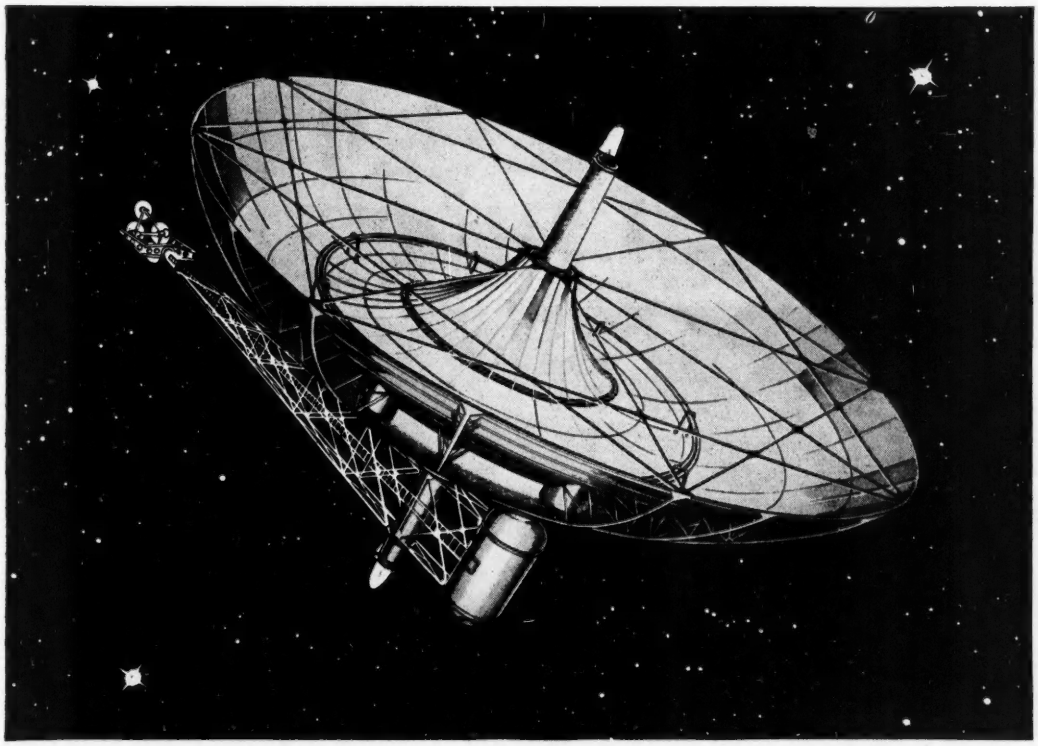
ENGINEERS IN THE BBC is an invitation to graduate engineers and physicists to consider a career in the BBC. The booklet says that the Engineering Division, at the beginning of this year, comprised some 4 500 staff, of whom about 600 are fully qualified engineers and physicists, and about 2 300 are engineers who may not necessarily be fully qualified academically. Each year the BBC offers a number of Graduate apprenticeships of two years' duration to engineers and physicists who obtain good Honours degrees. It also has opportunities for men with a pass degree, and a special course is being prepared for them. Copies of the booklet, which is being circulated to universities and technical colleges, can be obtained from the Engineering Establishment Officer, BBC, London, W.1.

WIRELESS WORLD DIARY 1956. Base connexions for 600 current valves, graphical design data and a directory on radio organizations in this country and abroad are included in this diary, which provides in tabloid form the kind of technical and general information frequently required by the radio man. The diary is now in its 38th year of publication. Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1. Price 5s. 10d. (leather), 4s. 1d. (rexine).

POWER FROM THE ATOM is a booklet published by the English Electric Co. Ltd. on the occasion of the "Atoms for Peace" Exhibition held in Geneva in connexion with the International Conference of Scientists on the Peaceful Uses of Atomic Energy, under the auspices of the United Nations, in August, 1955. The English Electric Co. Ltd., Queens House, Kingsway, London, W.C.2.

THE PHYSICS OF THE IONOSPHERE is the report of the Physical Society Conference held at the Cavendish Laboratory, Cambridge, in September, 1954. The Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7. Price 40s.

THERMIONIC VALVES 1904-1954 contains the lectures, by Sir Edward Appleton, Professor G. W. O. Howe and Dr. J. Thomson on the occasion of the celebration of the jubilee on 16 November, 1954 of Sir Ambrose Fleming's thermionic valve. Also included is the opening address by the Lord President of the Council and an appreciation of Sir Ambrose Fleming and Dr. Lee de Forest by Captain C. F. Booth, and a complete list of the exhibits, which ranged from Fleming's lamps and valves to travelling-wave tubes. The Institution of Electrical Engineers, Savoy Place, London, W.C.2. Price to members 4s., non-members 9s.



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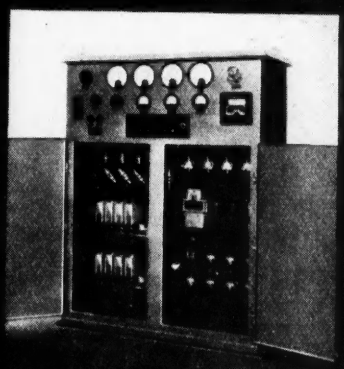

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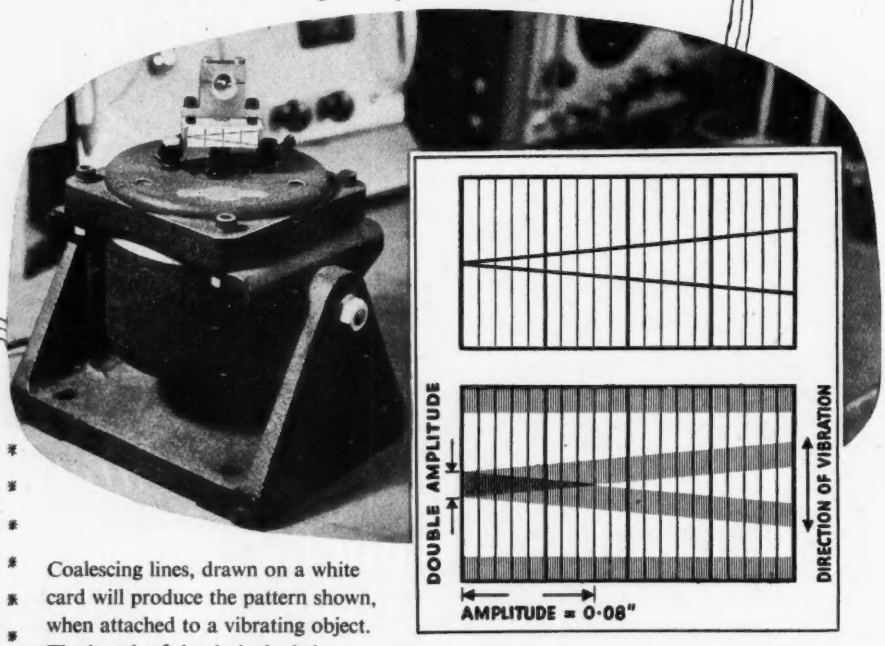
P. 1439

THE **FOURTH** IN A SERIES IN THE INTERESTS OF A BETTER UNDERSTANDING OF VIBRATION TECHNIQUE

do you know...?

that a measurement of vibration amplitude can be made using a simple line diagram



Coalescing lines, drawn on a white card will produce the pattern shown, when attached to a vibrating object. The length of the dark shaded triangle is then a measure of the amplitude. In the original triangle, the ratio of the height to half the base gives the apparent magnification, so that the vertical lines can be spaced to represent vibrations of known amplitudes.

e.g. If the base of the triangle is 0.4″ and the height 2″ then the magnification is 10 (see diagram). The vertical divisions spaced at 0.1″ will, therefore, represent a vibration amplitude of 0.01″. In the lower drawing the intersection occurs at the eighth division indicating a vibration amplitude of 0.08″. As the vibration amplitude is increased the apex of the shaded triangle can be seen to spread across the vertical divisions so that the amplitude can be quickly estimated.

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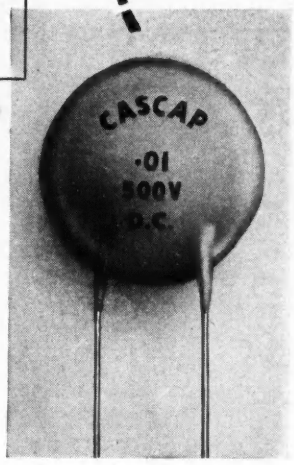

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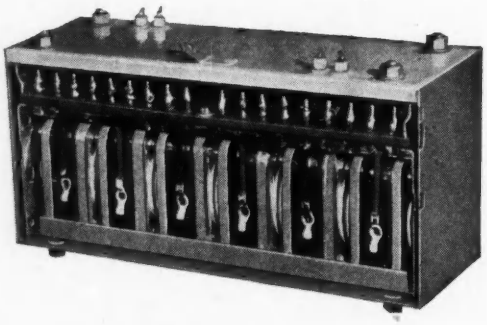

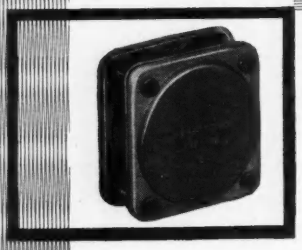

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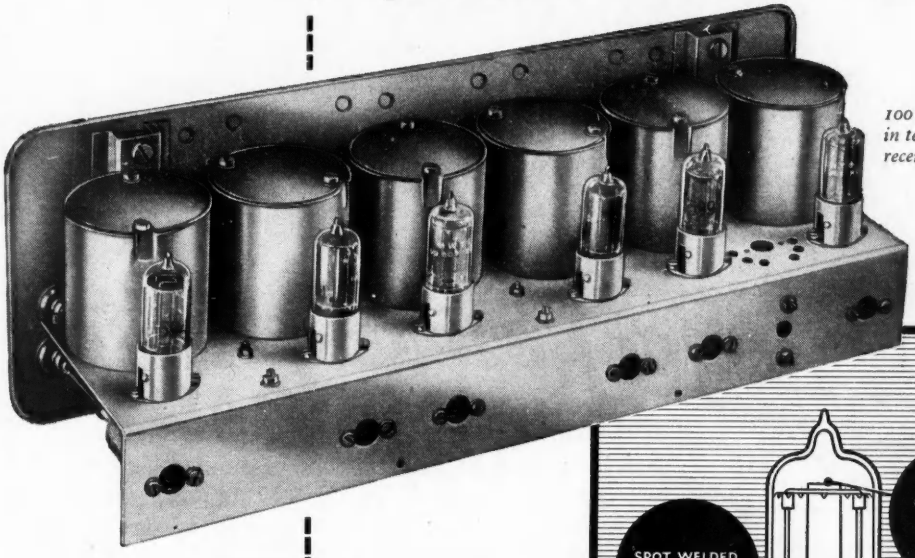

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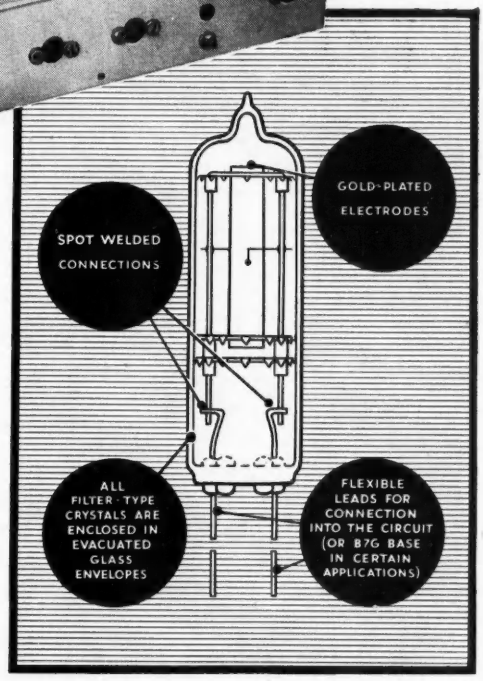
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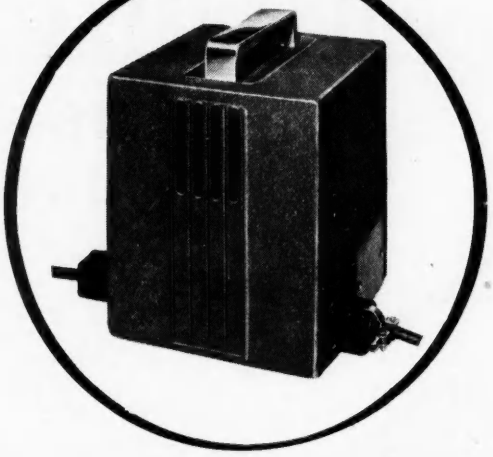

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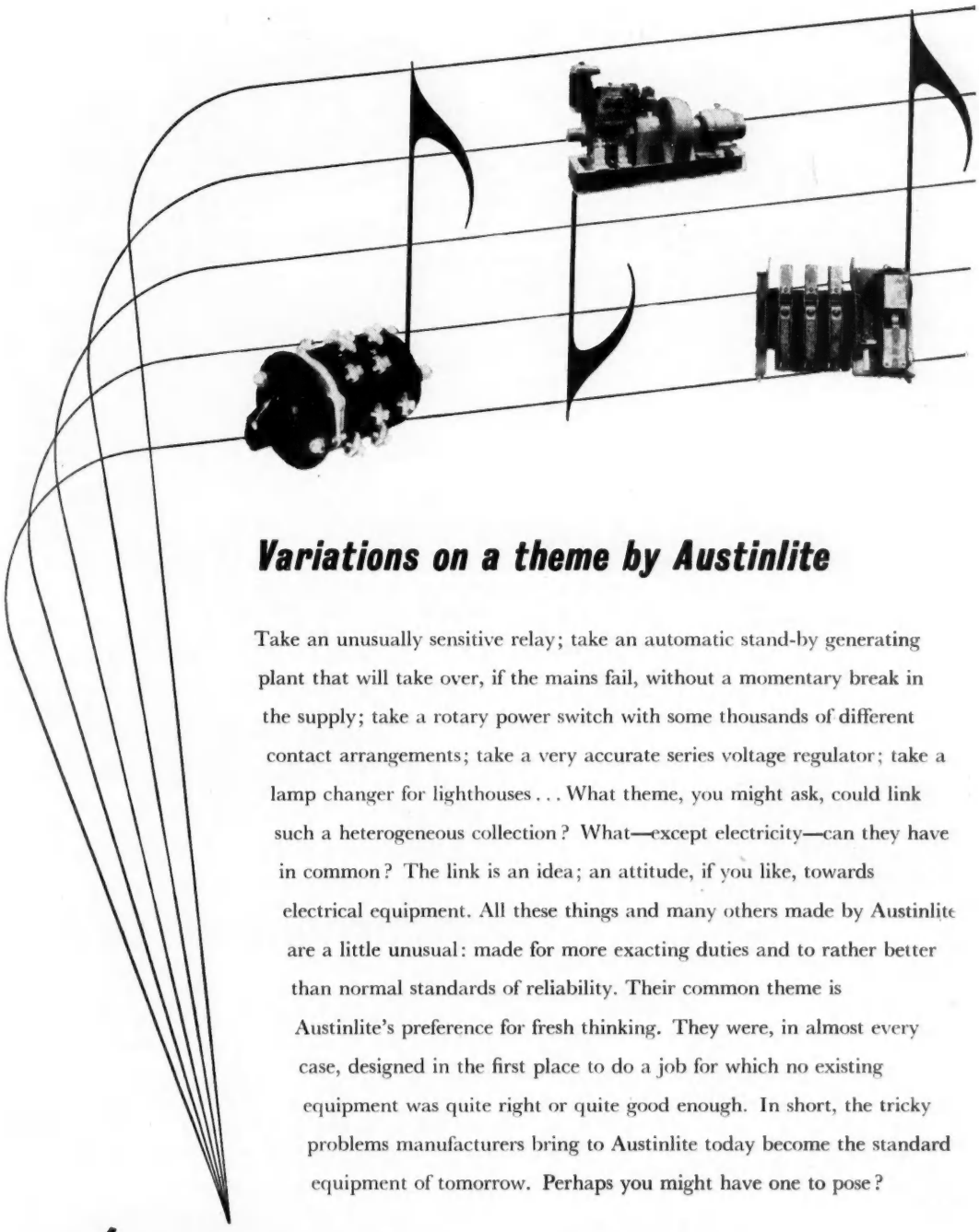

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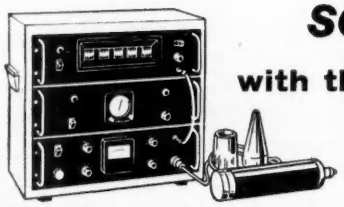

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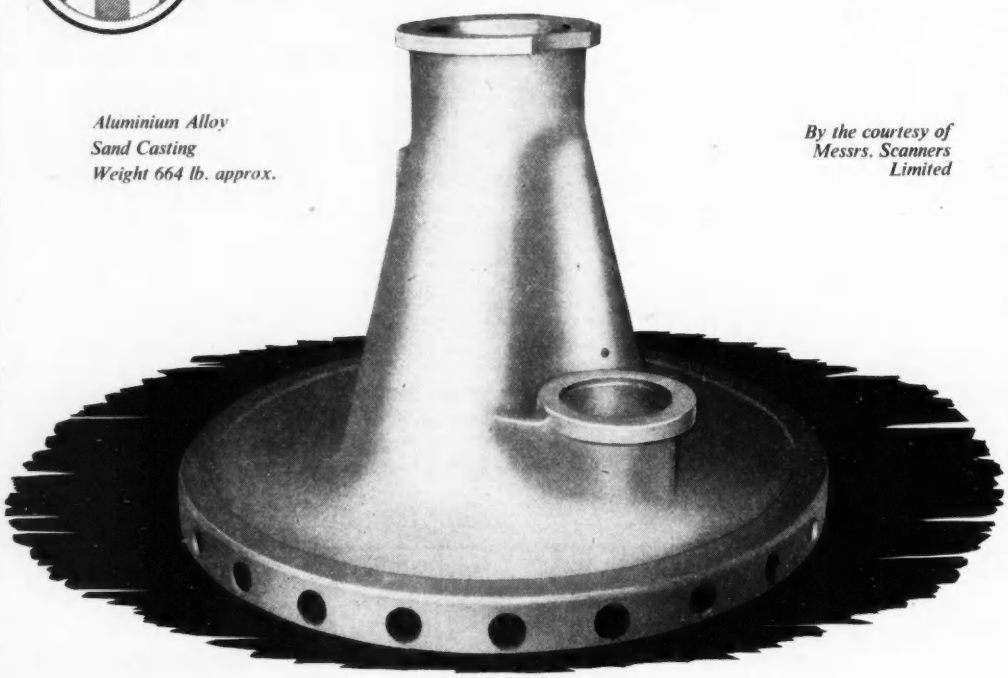

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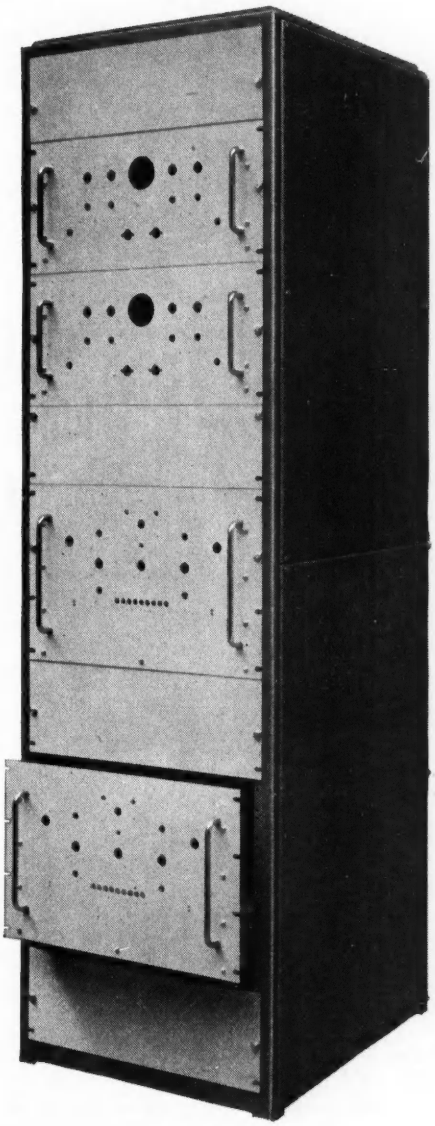

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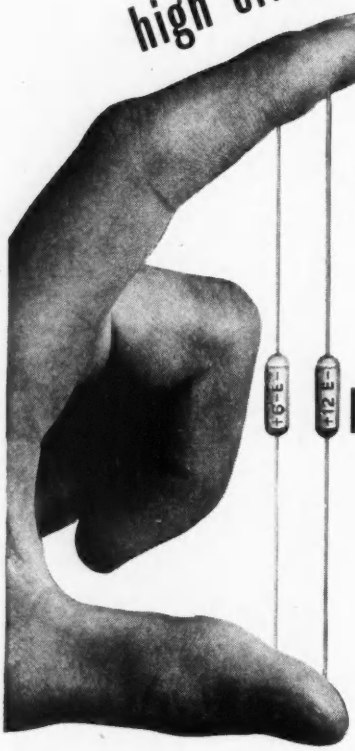

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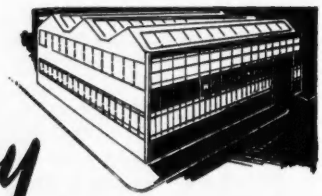

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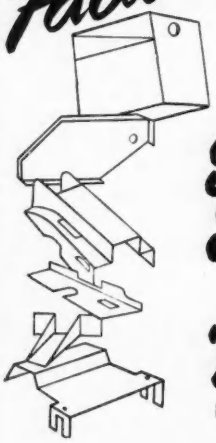

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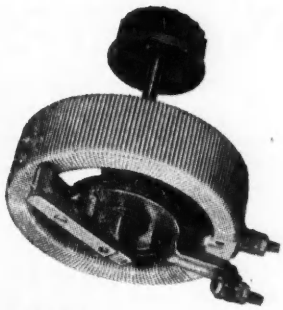
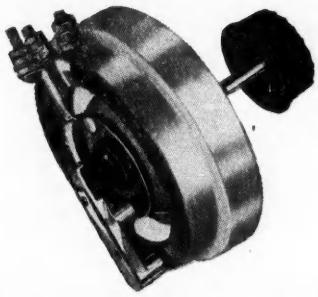


Open ring type.
Back of board mounting.



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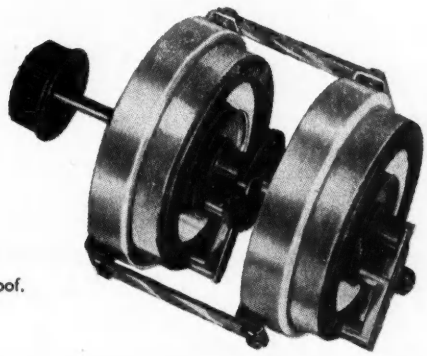
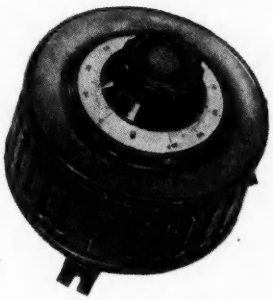
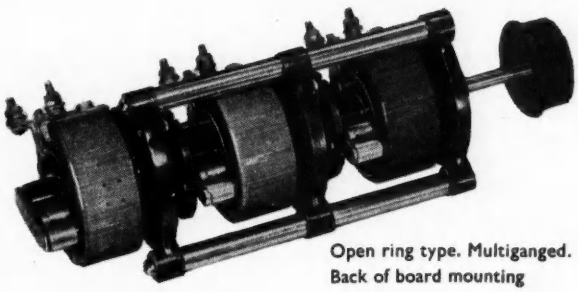




Enclosed ventilated type. Front
or back of board mounting.



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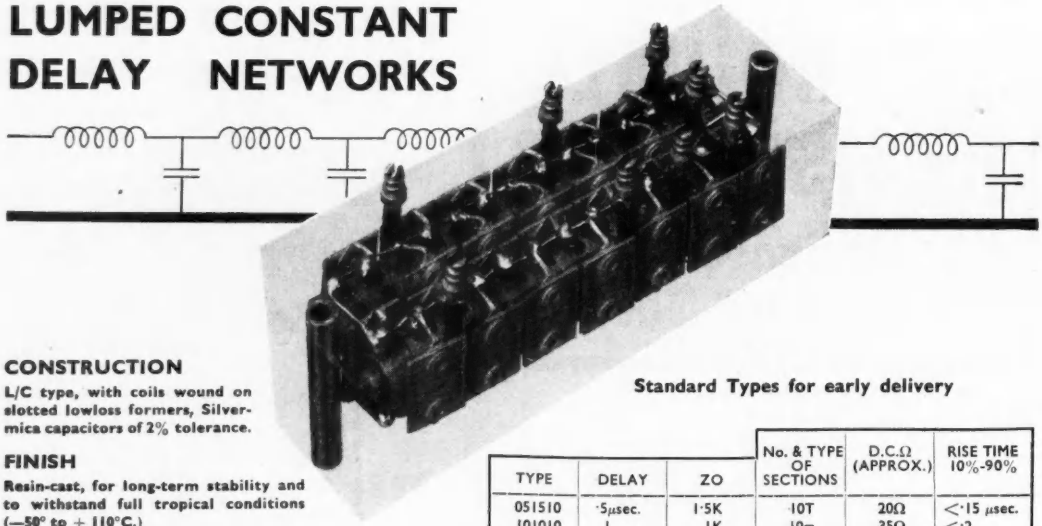

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101010	1 ,,	1K	10π	35Ω	<·2 ,,
100520	1 ,,	500Ω	20π	18Ω	<·15 ,,
202010	2 ,,	2K	10π	110Ω	<·35 ,,
205020	2 ,,	5K	20T	220Ω	<·3 ,,
402020	4 ,,	2K	20π	220Ω	<·45 ,,

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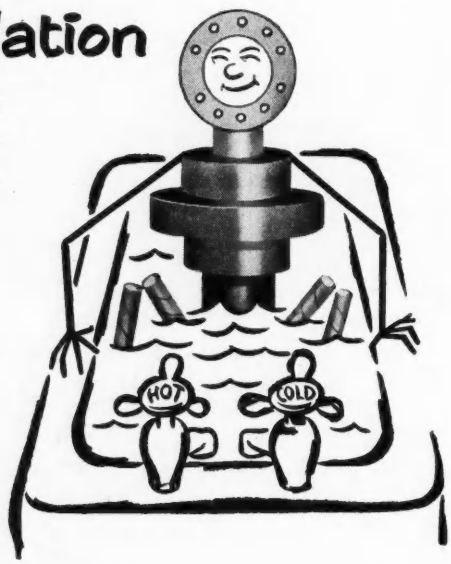

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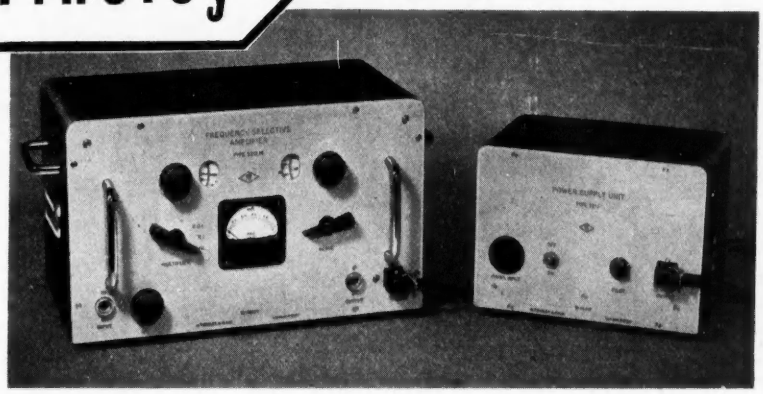

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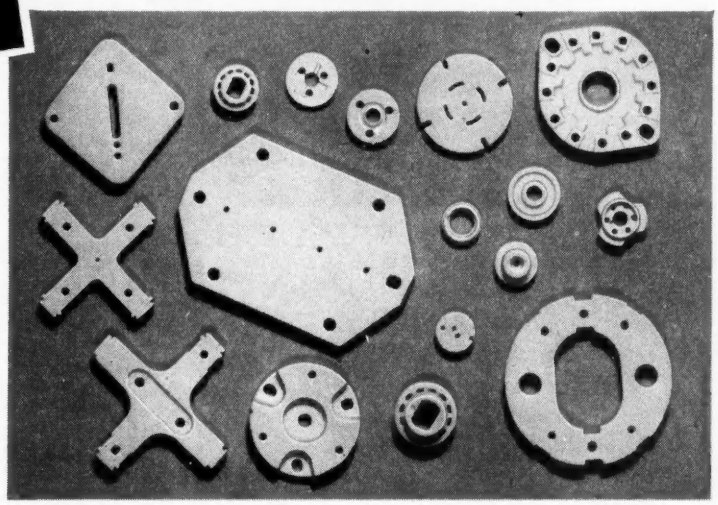

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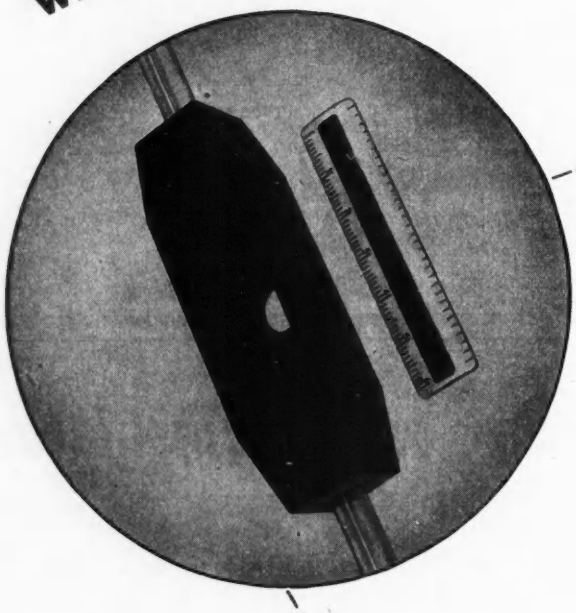

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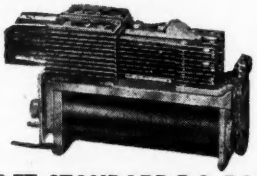

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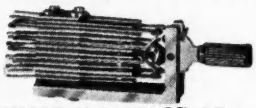

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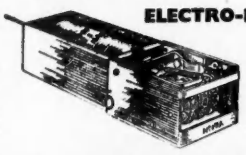

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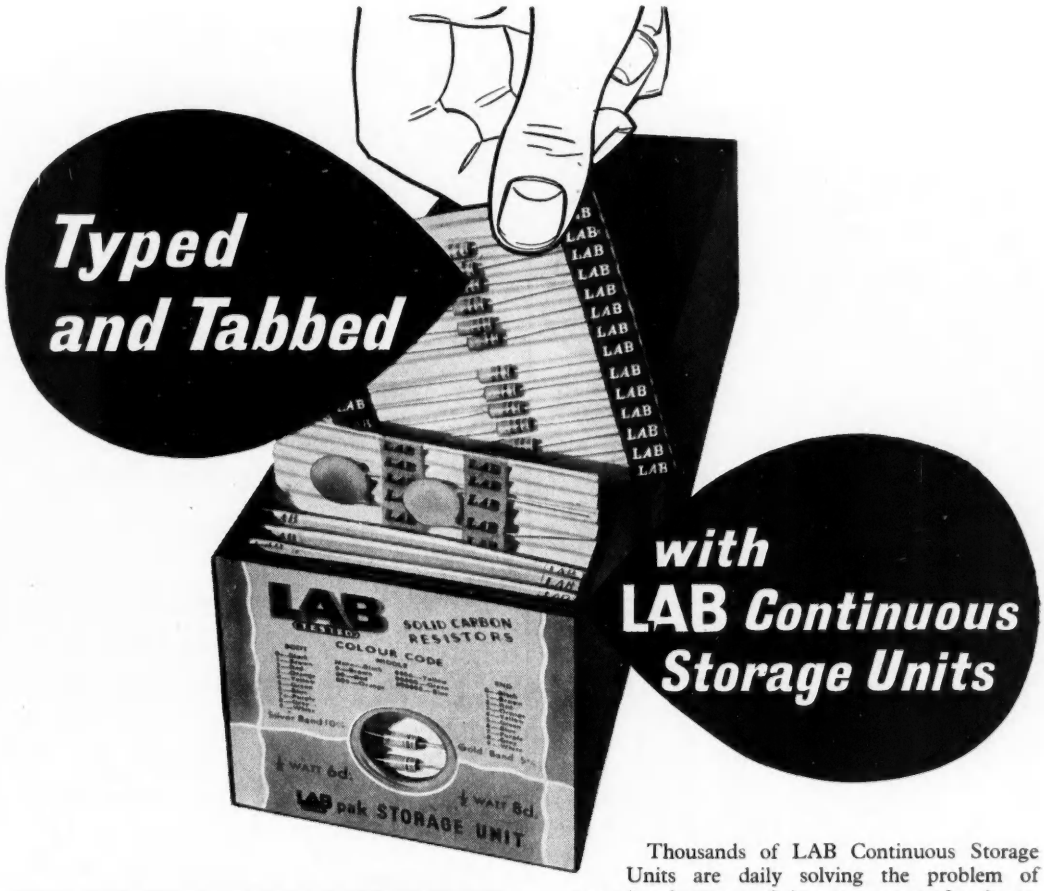

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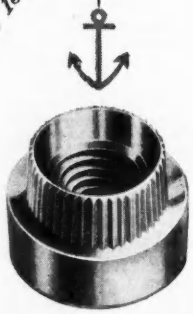

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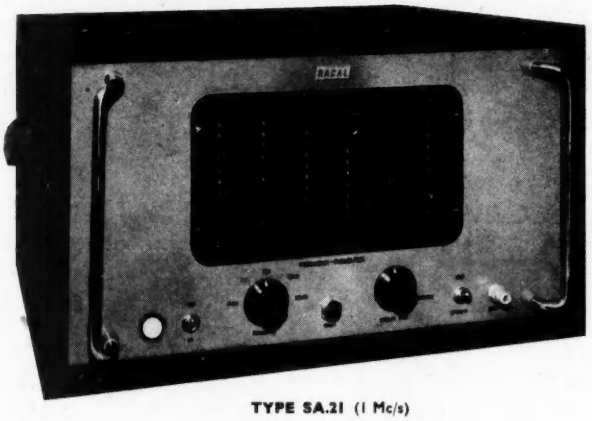

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The type SA.21 is representative of our range of instruments which will enable frequencies from 10 c/s to 30 Mc/s to be accurately and speedily measured. The individual "bricks" of these equipments such as Decade Counting Units, Time Generators, Amplifier-shaper—Gate and Dividing Units are all available separately in plug-in form. Full details will be supplied on request.

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R5/8	38H at 0·2	mA:	3200 ohms d.c.	primary
R11/14	4·5H at 0·8	mA:	500 ohms d.c.	primary
T20/23A	14H at 0·3	mA:	1200 ohms d.c.	primary
T20/23B	7H at 0·75	mA:	1200 ohms d.c.	primary
N20/23A	30H at 0·3	mA:	1500 ohms d.c.	primary
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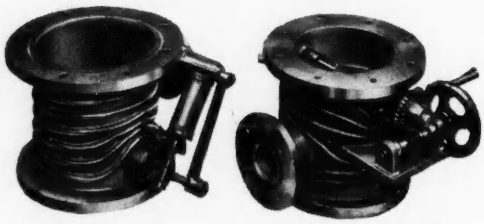

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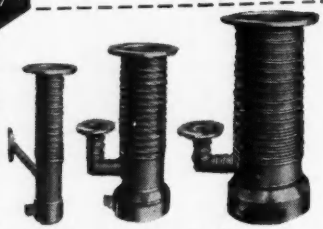
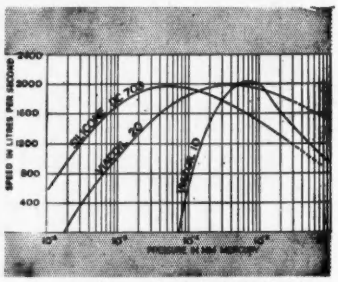


Type P1 *Type P6* *Type P10*



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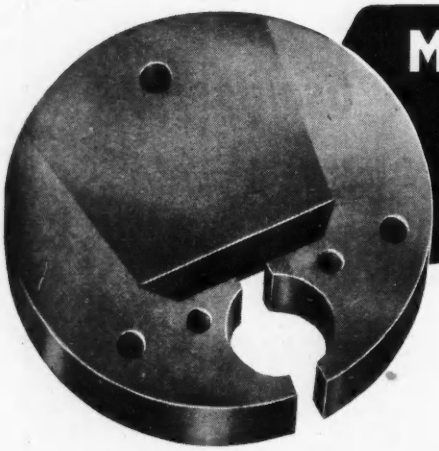

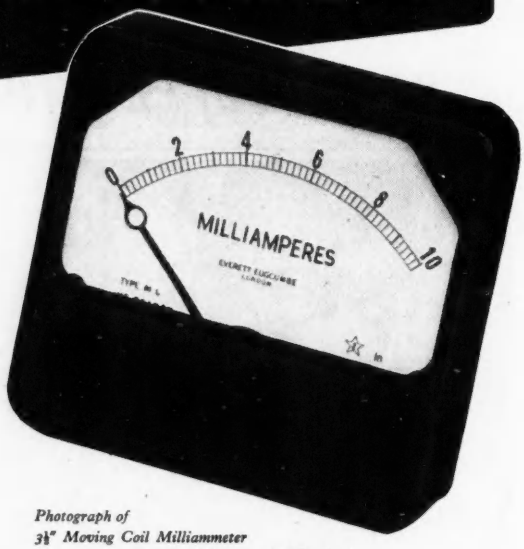

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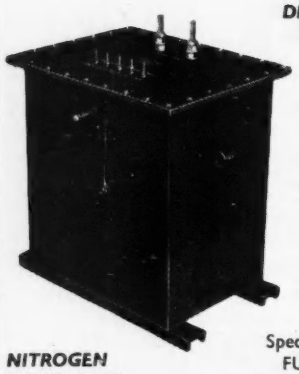

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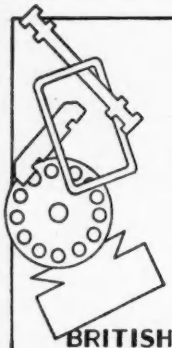

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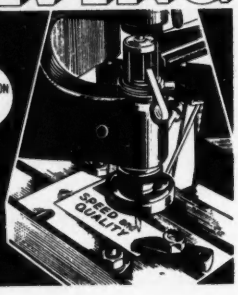

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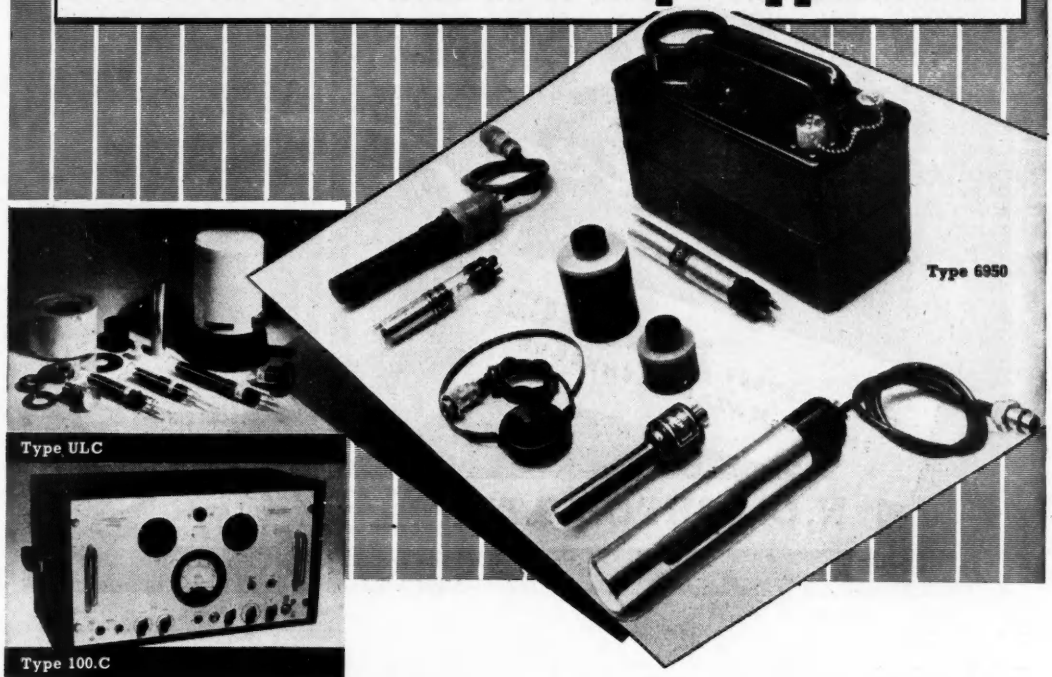
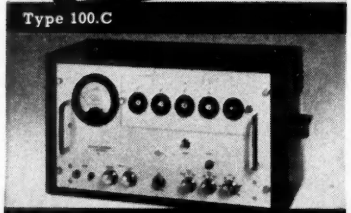
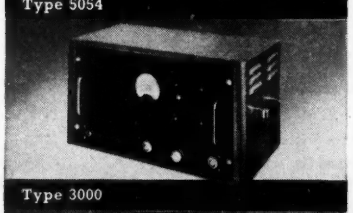


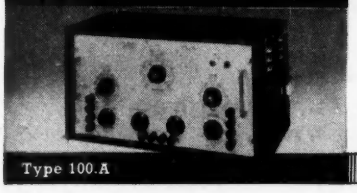
Type ULC

Type 100.C


Type D.554

Type 5054


Type 3000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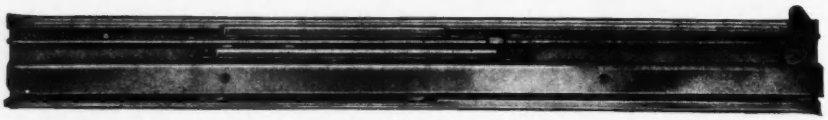

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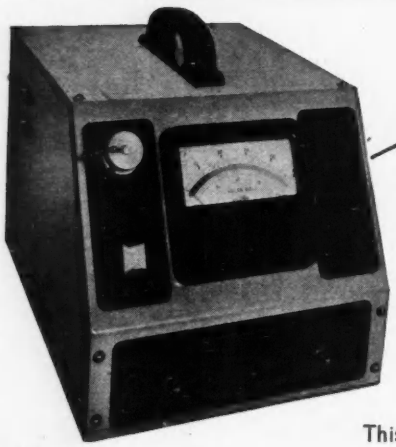

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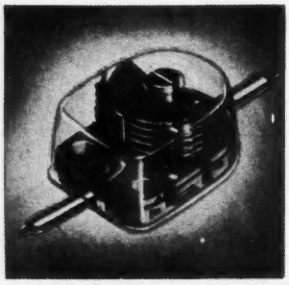

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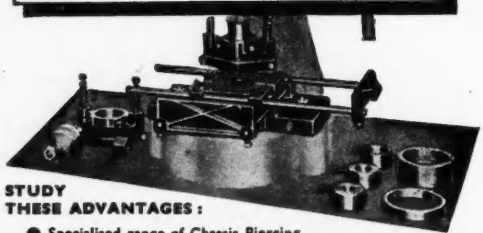

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SPECIFICATION

STROBOSCOPE TYPE 3

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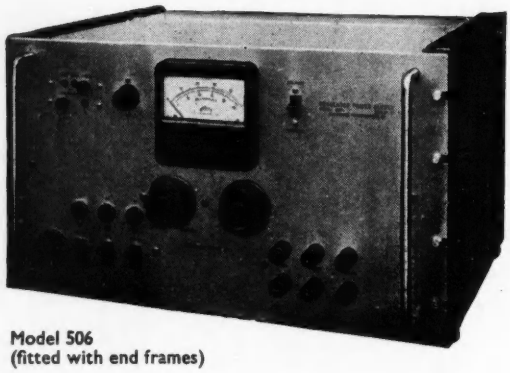

Model 506
(fitted with end frames)

ABRIDGED DATA

Data		Model 506	Model 507	Model 508	Model 509
Main +VE Stabilizer	Output	200-500V 350mA	200-500V 350mA	0-500V 350mA	0-500V 350mA
	Number of Ranges	2	2	4	4
	Voltage Stabilization	±0.02%	±0.002%	±0.1%	±0.002%
	Effective Output Resistance (max.)	0.2 Ω	0.02 Ω	0.5 Ω	0.02 Ω
	Output Ripple (rms. max.)	2mV	1mV	3mV	1mV
—VE Supply Stabilizer	Outputs	—	—	250V 25mA 0-250V 1mA	250V 25mA 0-250V 1mA
	Voltage Stablization	—	—	±0.05%	±0.002%
	Output Resistance (max.)	—	—	1 Ω	0.01 Ω
	Output Ripple (rms. max.)	—	—	2mV	1mV
Unstabilized +VE H.T. Supply 350mA max.		470V 630V	470V 630V	320V 470V 630V	320V 470V 630V
Unstabilized A.C. Supply		6.3V 10A	6.3V 10A	6.3V 10A	6.3V 10A
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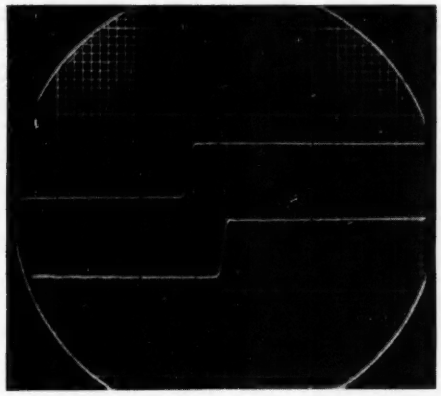
DE103 Square Wave leading edges at 2"/μsec illustrating rise times.



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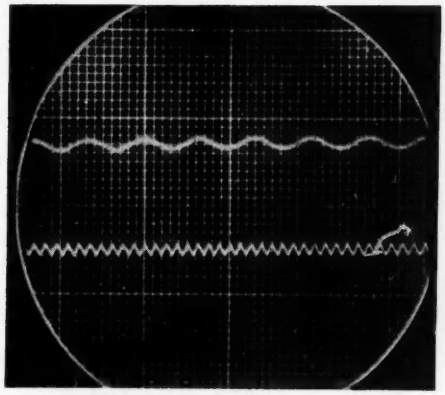
DT103 20μV RMS applied to both channels at 100,000 gain showing noise level. Upper trace expanded X5.



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Calibrated for time and voltage measurements to 5 per cent.

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Both instruments are easy to use, reliable, made to very high standards and are now in production.

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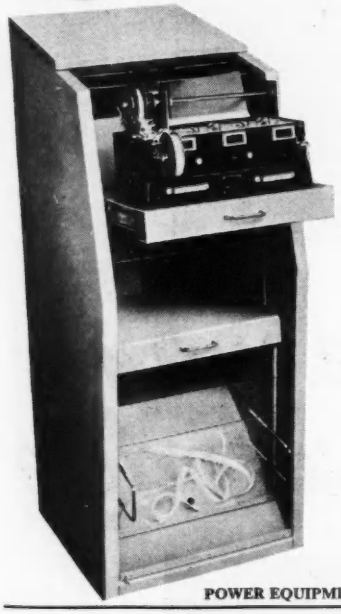

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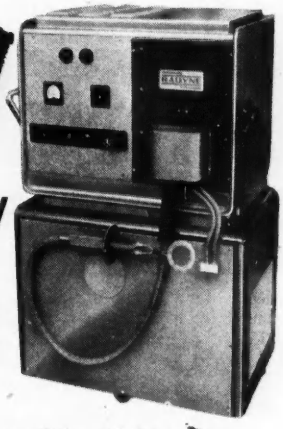

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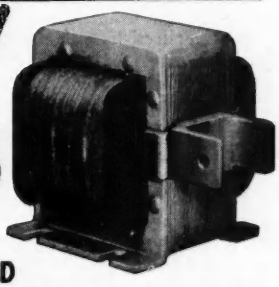

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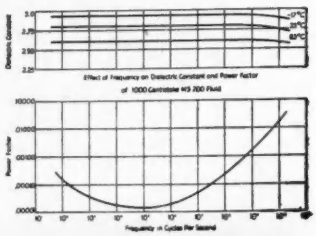

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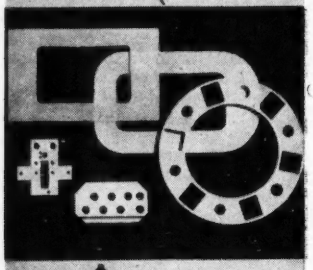

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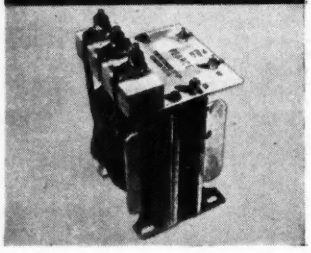

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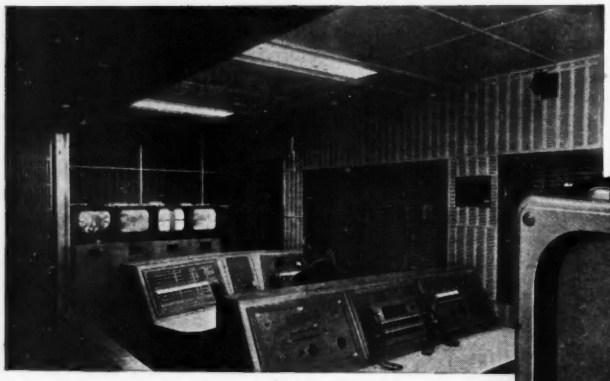

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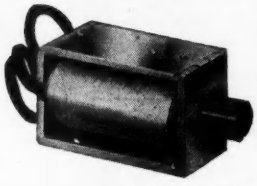

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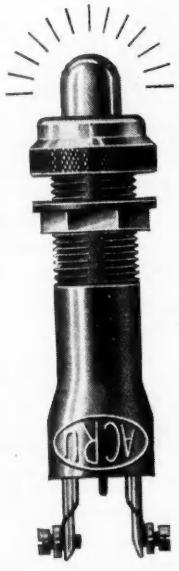

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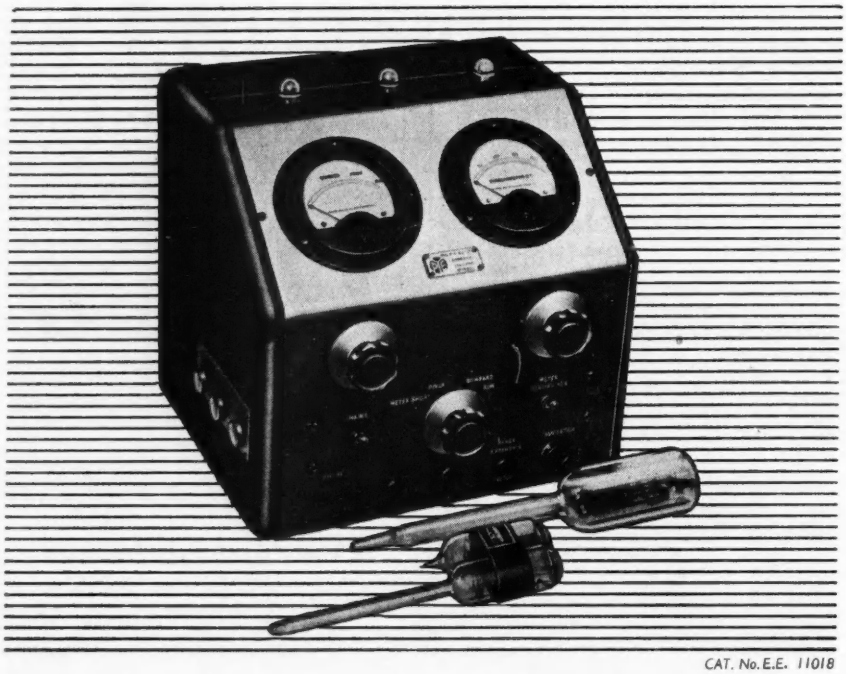

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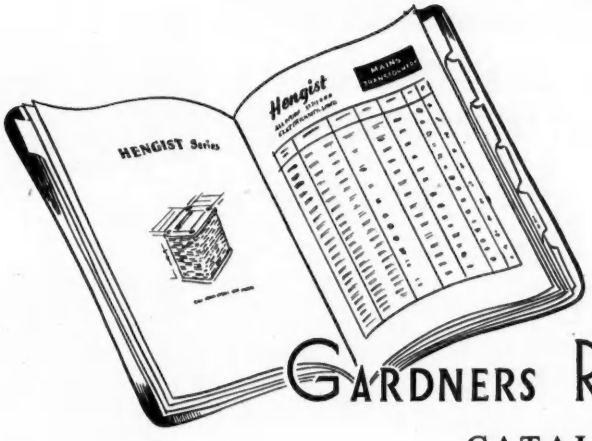

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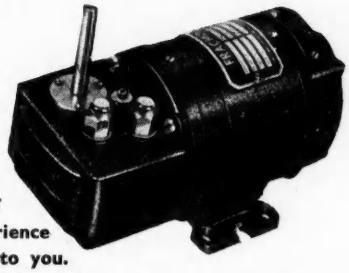

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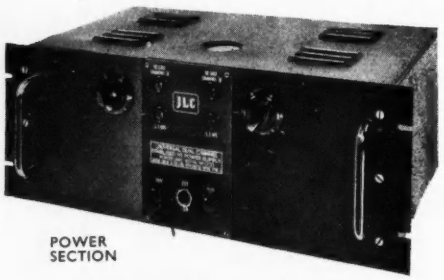

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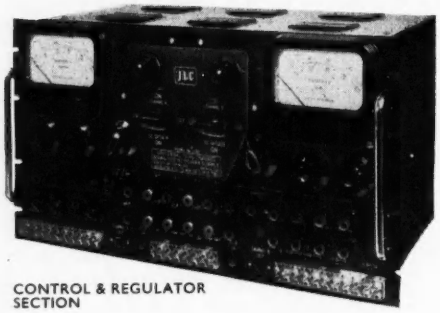

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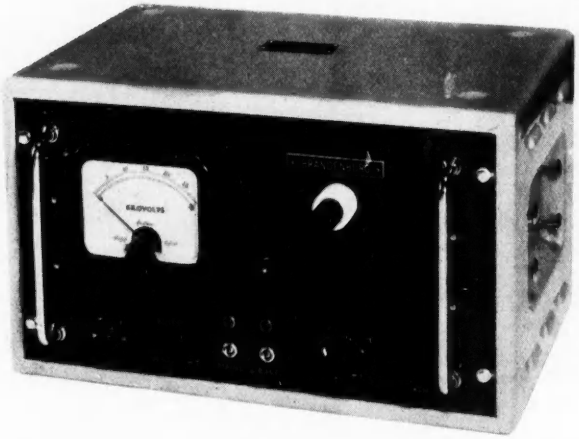

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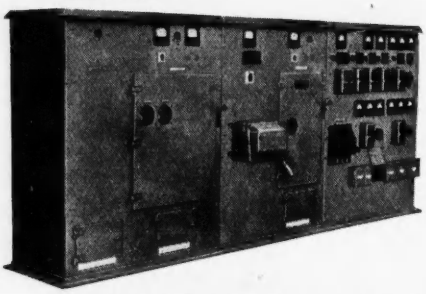

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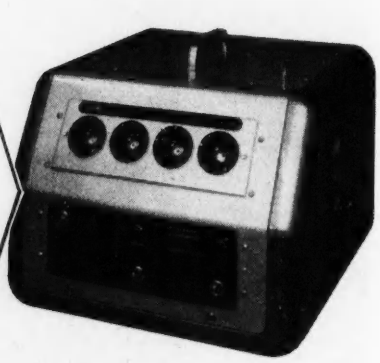

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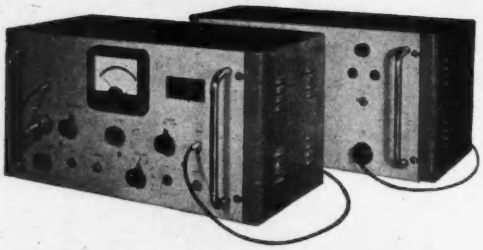

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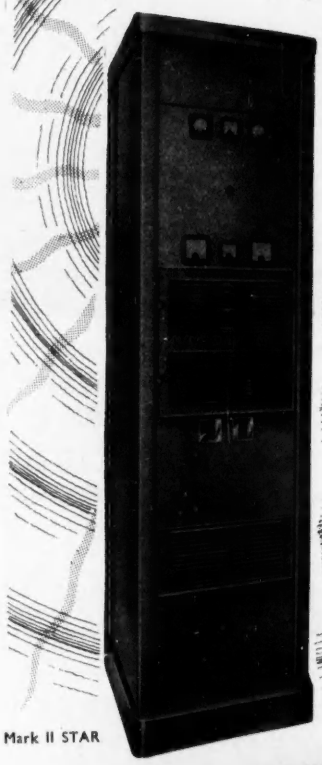

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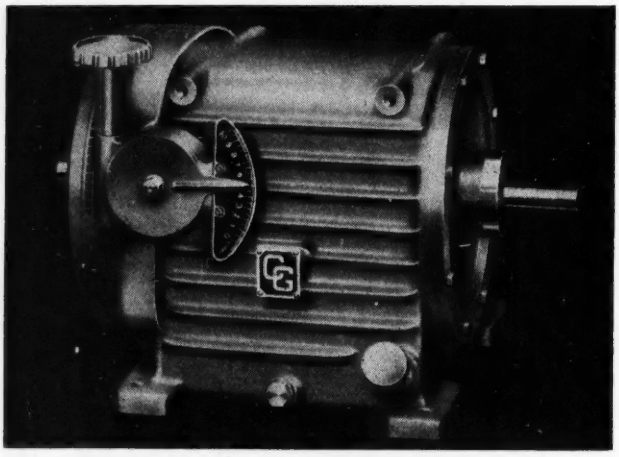

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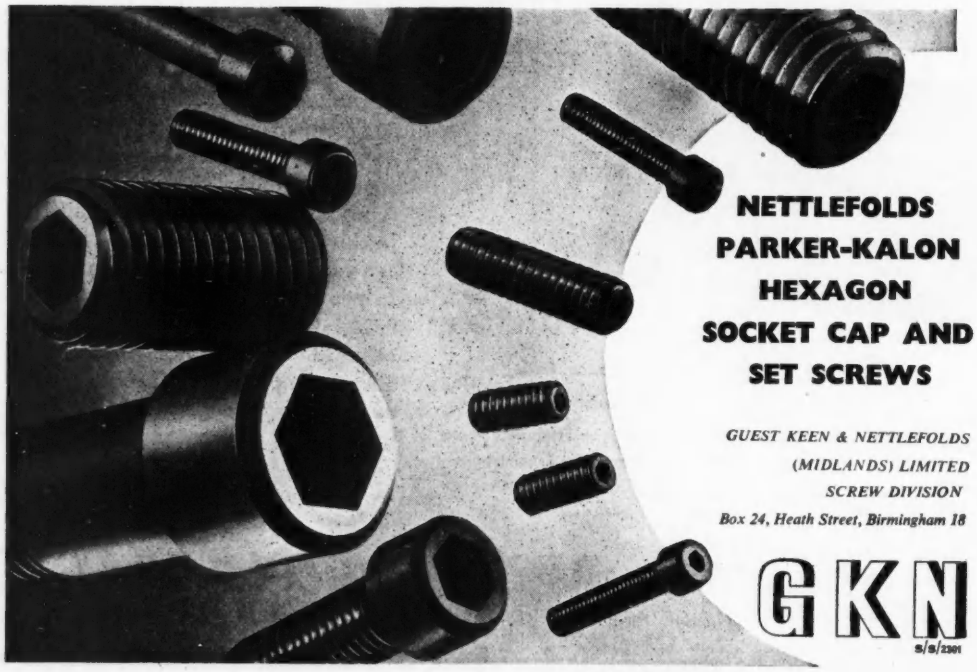

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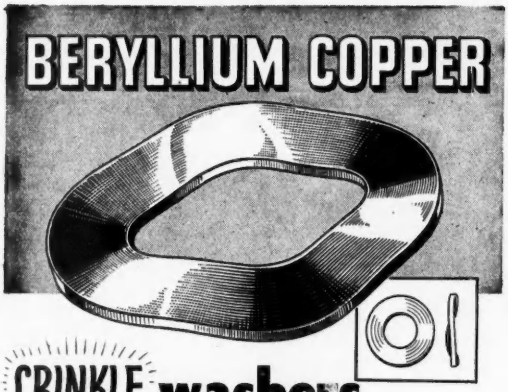

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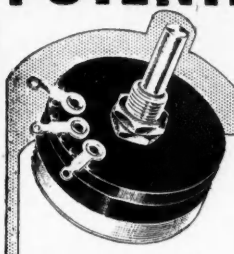

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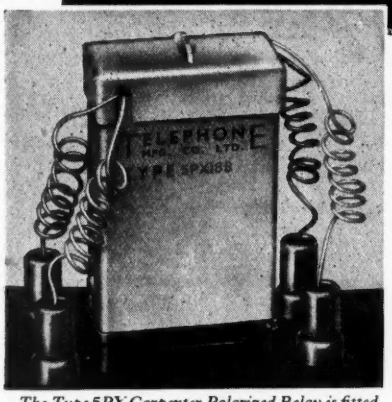

The Type 5PX Carpenter Polarized Relay is fitted with platinum contacts to reduce thermal noise, and has flying contact leads to reduce "pick-up" in contact circuit due to the coil. DIMENSIONS: *Height* 2.5 *in. Width* 1.6 *in. Depth* 0.8 *in. Approx. weight* 4.8 *oz.*

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The Type 5PX relay has platinum contacts so that contact noise voltages are considerably reduced. Moreover, screening between coil and contact circuits—and flying contact leads, reduce to negligible proportions possible trouble due to "pick-up" from the coil. Where frequencies in excess of 50 c/s are required, specialized versions of the larger Type 3 relay can be used.

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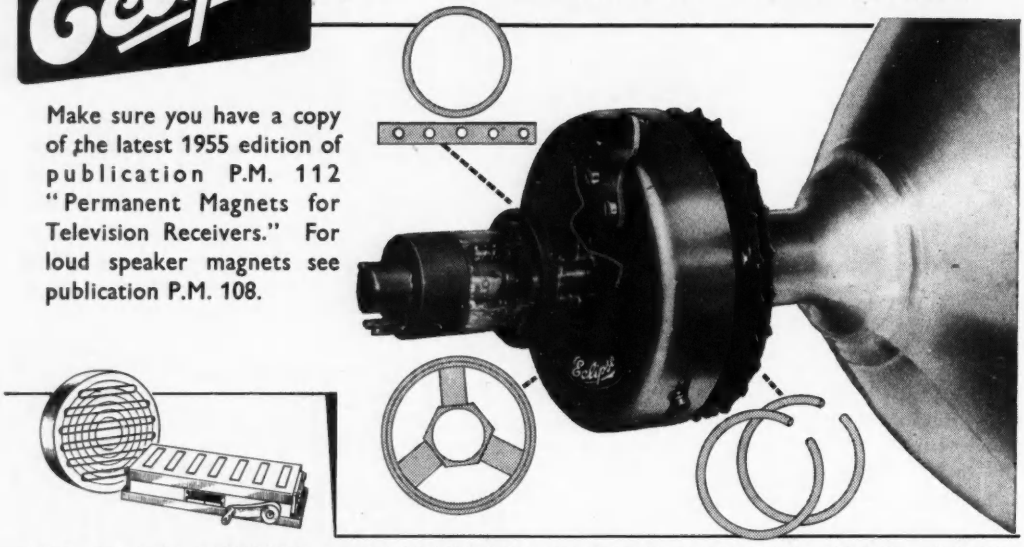

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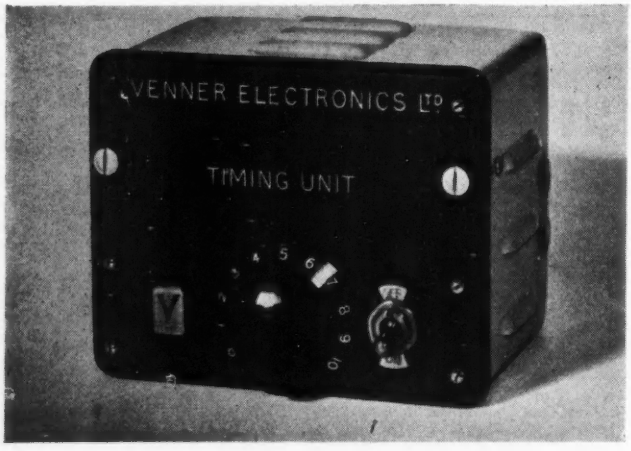

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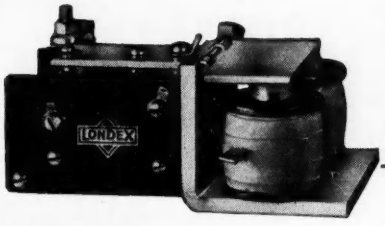

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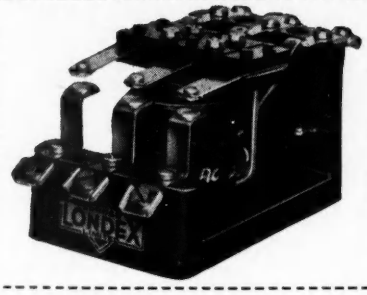

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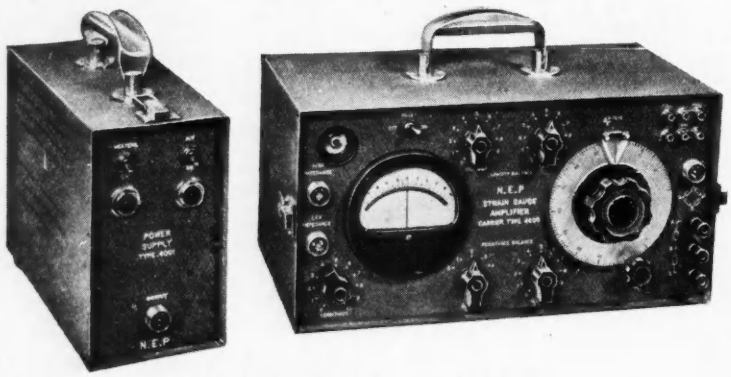

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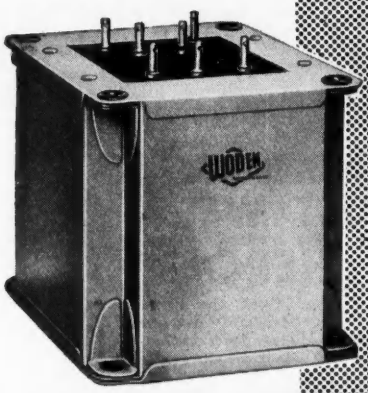

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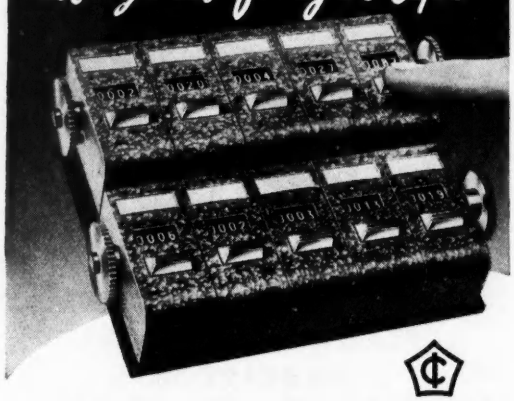

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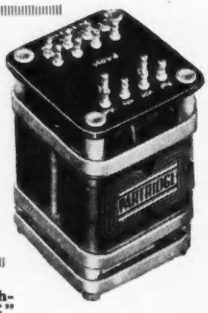

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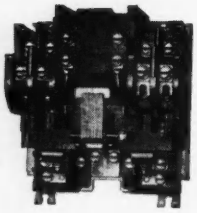

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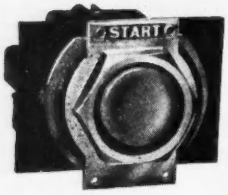

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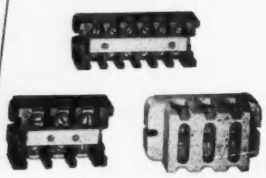

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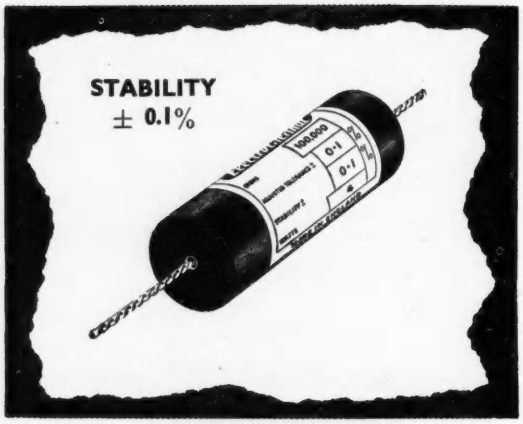

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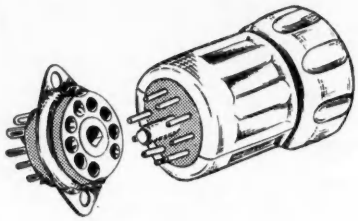

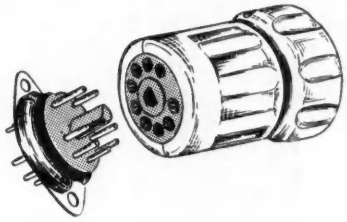

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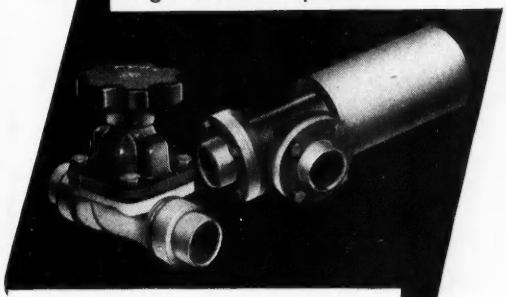

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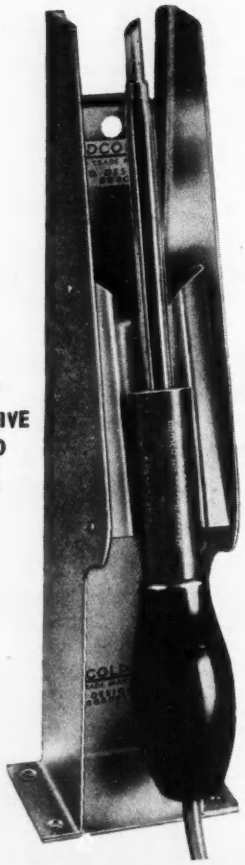

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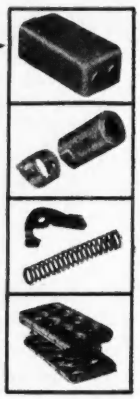

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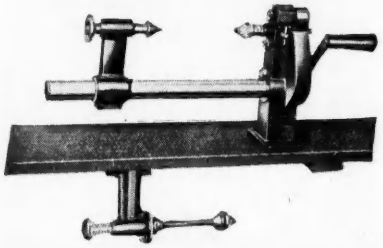

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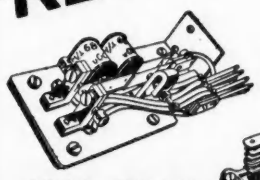

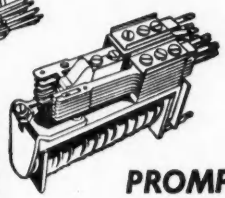

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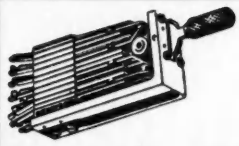

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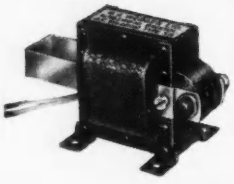

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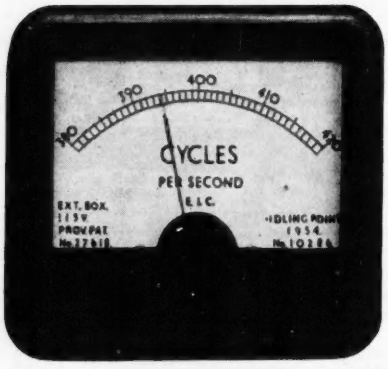

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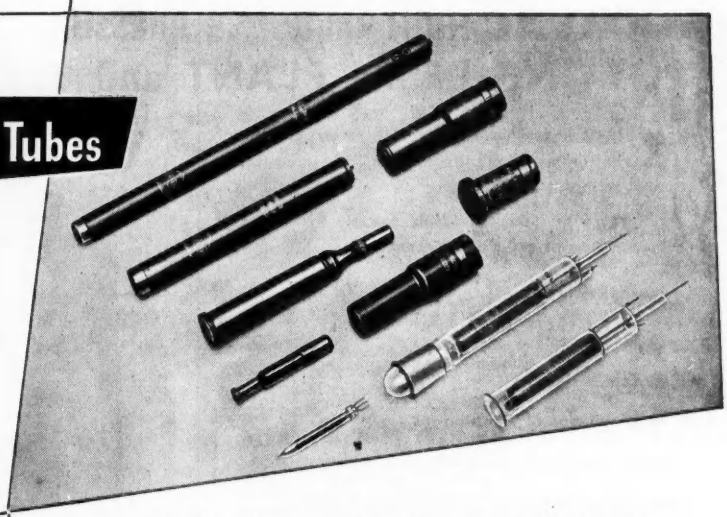

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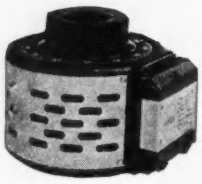

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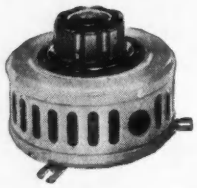

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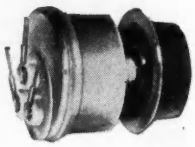

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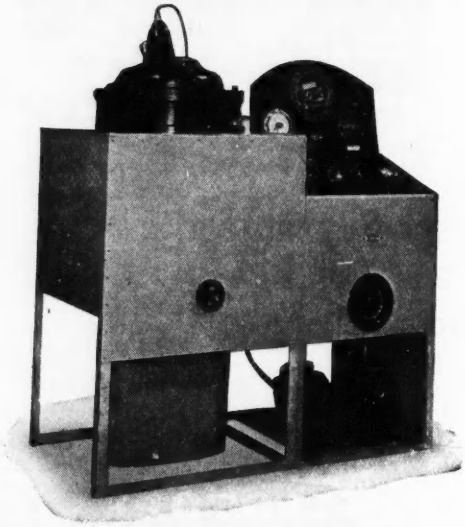

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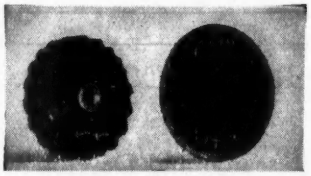

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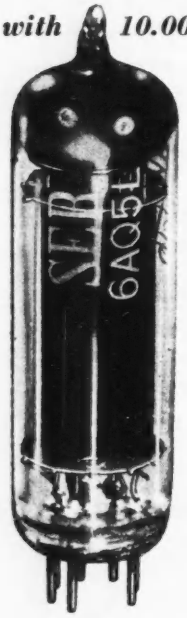

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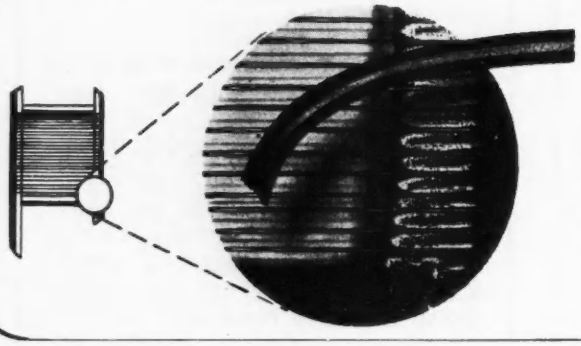

Compared with a human hair . . .

The illustration shows a magnified portion of the grid frame and a few turns of the control grid winding of the wide band pentode 404A. The grid lateral wire has a diameter of 0.0003 in. and a breaking point of only 340 grains. It is gilded to prevent grid emission and to permit perfect soldering to the frame. By way of comparison a human hair has been placed across the grid winding.

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PRE-PRODUCTION FROM A TO Z

HANDLING PRE-PRODUCTION RUNS straight from the development stage is an established feature of the Broxlea sub-contracting service. For the special-purpose amplifier shown here, as with other "first-off" jobs, we started by proving the drawings, compiling the initial parts list, and planning the two cable-forms required—followed by the straightforward production operations of assembly and wiring up to the A.I.D. standard normally observed in this class of work.

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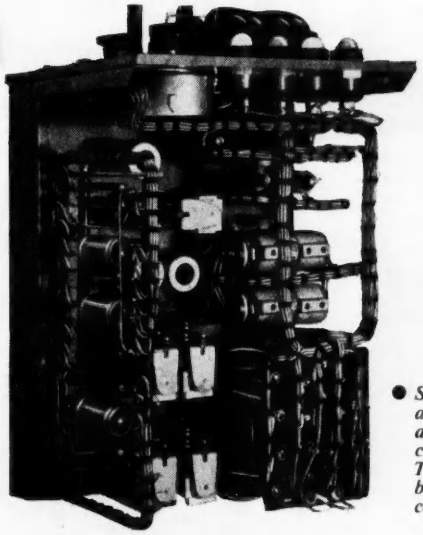

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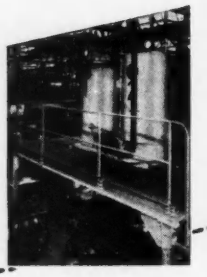

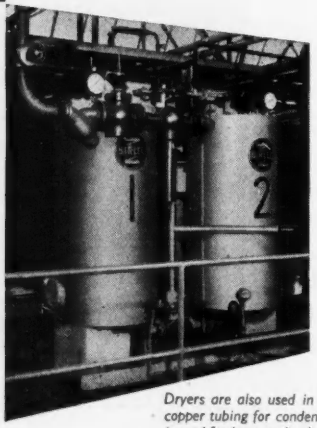

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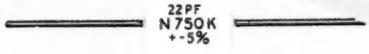

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	K	L	M	AD	BD	CD	A	B	C
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DIM. D MAX.	0.255"	0.255"	0.375"	0.240"	0.240"	0.315"	0.200"	0.200"	0.250"
	CAPACITANCE RANGE PF								
P100	Up to 10	11 – 22	23 – 90	Up to 10	11 – 22	23 – 90	Up to 10	11 – 22	23 – 90
NPO	Up to 18	19 – 42	43 – 130	Up to 18	19 – 42	43 – 130	Up to 18	19 – 42	43 – 130
N030	Up to 18	19 – 45	46 – 133	Up to 18	19 – 45	46 – 133	Up to 18	19 – 45	46 – 133
N080	Up to 21	22 – 53	54 – 155	Up to 21	22 – 53	54 – 155	Up to 21	22 – 53	54 – 155
N150	Up to 24	25 – 60	61 – 176	Up to 24	25 – 60	61 – 176	Up to 24	25 – 60	61 – 176
N220	Up to 27	28 – 66	67 – 194	Up to 27	28 – 66	67 – 194	Up to 27	28 – 66	67 – 194
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N470	Up to 36	37 – 88	89 – 260	Up to 36	37 – 88	89 – 260	Up to 36	37 – 88	89 – 260
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N1500	10 – 60	61 – 147	148 – 430	10 – 60	61 – 147	148 – 430	10 – 60	61 – 147	148 – 430
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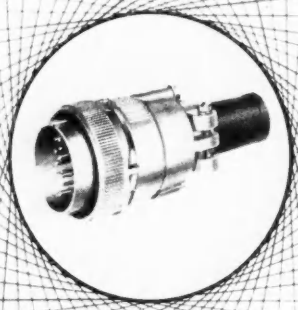

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